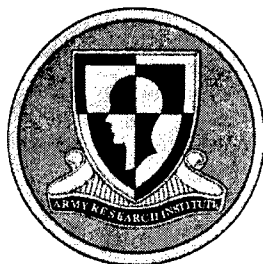**Special Report 62**

U.S. ARMY RESEARCH INSTITUTE
PROGRAM IN BASIC RESEARCH
FY 2004

Research and Advanced Concepts Office
(RACO)

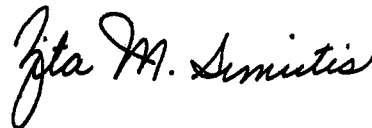**20060317 001**

August 2005

**U.S. Army Research Institute
for the Behavioral and Social Sciences**

**A Directorate of the Department of the Army
Deputy Chief of Staff, G1**

Authorized and approved for distribution:

Zita M. Simutis

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Director

NOTICES

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THE BASIC RESEARCH PROGRAM:
IDENTIFYING NEW AND PROMISING TECHNOLOGIES

The Research and Advanced Concepts Office (RACO) research program focuses on providing the the basic research underpinnings for the personnel, leader development, and training requirements of the future. This program is a critical link between the world of behavioral science and the military community. Searching out and advancing the state-of-the-art methods, theories and findings in behavioral science, encouraging projects most likely to contribute generalizable scientific principles and new knowledge, and supporting those efforts that have potential military relevance and likelihood of leading to applied behavioral technology are RACO's key research goals.

Universities conduct most of the basic research program. RACO maintains close contact with other basic behavioral science research organizations as well as with ARI's applied researchers and other relevant agencies within the Army and other military services. These contacts help to define issues that require fundamental research, and facilitate the transition of basic research results to applied programs for eventual use by the operational Army.

In RACO's contract programs, a Broad Agency Announcement (BAA) is issued each year to solicit both concept papers and formal proposals relating to the announced program research areas. In a given year, the BAA highlights the research objectives of special interest, and provides an open call for proposals.

On the following pages, the reader will find summaries of current and recently completed RACO contracts, which began between 2000 and early 2005. There are three current RACO program objectives, each of which will be discussed in detail below. These objectives are as follows:

1. To provide fundamental knowledge to improve training in complex environments,
2. To provide fundamental knowledge to improve leader and team performance,
3. To provide fundamental knowledge for identifying, assessing, and assigning quality personnel in the evolving Army.

Training for Complex Environments
Basic research in this area focuses on developing concepts and methods for training complex tasks and for sustaining complex task performance. Assessing the cognitive impact of technology requirements arising from digital, semi-automated, and robotic systems on training requirements is also part of this process. One of the efforts in this area seeks to understand the impact of the voluminous multi-modal data on performance and how individuals and teams might be trained to integrate and use such rapidly presented data. We seek to identify unique training principles and methods for improving interpersonal skills and team adaptability and performance. The expected outcome is applied research testing the principles and methods produced in this work package in Army training environments. The models and theories produced should be useful in accounting for individual differences in training and facilitating practical, individualized, adaptive training methods. These advances will translate into improved training methods in a wide range of tasks.

Improving Leader and Team Performance
Commensurate with the requirements for rapidly developing adaptable, flexible leaders, the basic research program in improving leader performance is directed toward providing concepts and methods for accelerating leader development and understanding and developing leader adaptability and flexibility in a manner that can be tested in the applied environment. One of our major efforts in this area uses Sternberg's theory of practical intelligence to develop new techniques for acquiring experience-based, tacit knowledge as a means for rapidly developing effective military leaders. We are also committed to discovering and testing the basic cognitive principles that underlie effective leader-team performance. Understanding the dynamics of small group leadership in face-to-face and distributed team environments is a key aspect of the current basic research program in leadership. For example, one of our research projects seeks to develop leadership techniques that foster interaction, communication, and trust in electronic environments. Another examines the development of team leadership behaviors under the stress of performing in a metropolitan hospital shock trauma center and in the laboratory. We anticipate that results from this research will make an important contribution to understanding and improving organizational effectiveness.

Quality Personnel for the Evolving Army
Identifying and measuring the aptitudes and skills that are unique to the human performance requirements of military service is a major theme of this basic research effort. As part of this process, we seek to devise methods that assess mental flexibility and adaptability, describe how these attributes develop, and measure their contribution to performance and job tenure. For example, one of our efforts seeks new ways to conceptualize and assess individual mental flexibility since mental flexibility plays a critical role in the successful application of the mental processes needed for adapting to, selecting, and shaping the environment in novel situations. Exploring the sociological and psychological factors that could influence recruitment, retention, and performance is part of the work in this area as well. Applied research that builds the understanding of the cognitive processes entailed in flexible thinking can be used to identify those who are flexible, adaptable thinkers and to develop these skills through effective instructional programs that facilitate the use of flexible thinking strategies in a variety of contexts.

This document provides a listing and brief synopsis of ongoing and recently completed research efforts. Project listings are organized into the three aforementioned research objectives. It is important to note, however, that basic research is but one of many programs for which RACO has responsibility. Other programs in RACO include:

- Small Business Innovative Research (SBIR) Program,
- Small Business Technology Transfer (STTR) Program,
- International Behavioral Science and Technology Watch,
- Graduate student apprenticeship program - Consortium Research Fellows Program – with the Consortium of Metropolitan Washington Universities,
- Outreach efforts to Historically Black Colleges and Universities (HBCUs) and Minority Institutions (MIs), and
- Research support in behavioral science for the U.S. Military Academy.

Additional information about reports from these research efforts is available upon request.
Paul A. Gade, Chief, Research and Advanced Concepts Office
Laura Wheeler Poms, Consortium Fellow, Research and Advanced Concepts Office

RACO RESEARCH OBJECTIVE #1:

Provide fundamental knowledge to improve training in complex environments.

Research under this objective develops concepts and methods for training complex tasks and sustaining complex task performance. The focus is on understanding the cognitive impact of Future Force technology on training requirements, the impact of voluminous multi-modal data on performance, and developing methods for improving cognitive skills.

Training For Rapid Interpretation of Voluminous Multi-modal Data

Contract #: DASW01-02-K-0001
Institution: Georgia Institute of Technology

Contract Dates: 5/1/02-1/31/05
PI: Dennis J. Folds
Liaison: Scott Graham, IFRU

Problem(s)/Research Question(s) – How do people make decisions when they must process a large volume of data very quickly? What types of errors do they commonly make? Can we train people to avoid common errors in this type of decision making?

Technical Barrier(s) – Theoretical basis for understanding rapid decision making is not well developed.

Significance/Impact for Basic Research – Understanding characteristic errors in rapid decision making will lead to better understanding of underlying decision processes.

Potential Transitions – Knowledge gained in this basic research may be usefully employed in the following Army applied research programs:
- Future Force Warrior Training (WP 215)
- FUTURE-TRAIN: Techniques and Tools for C4ISR Training of Future Brigade Combat Team Commanders and Staffs (WP 211)

Overview

The primary goal of our research is to increase understanding of how individuals and small teams make decisions when they must process a large amount of information very rapidly. A second goal is to determine how to improve this ability through training. We study the effects of data format (photographs, audio files, video clips, text messages, computer graphs, and map-based icons) on rapid decision making. We also study the effects of overall information volume (i.e., the total number of information items that a person must process before making a decision) and information density (i.e., the number of information items relevant to the decision). We identify the types of errors that people commonly commit when making decisions in this manner and are studying different ways to improve performance through training.

We are conducting a series of laboratory experiments with individuals and small teams. The specific objective for each experiment is as follows:
- Experiment 1 – Assess the effects of data format, density, and overall volume on decision making performed by individuals.
- Experiment 2 – Assess effectiveness of anti-bias training for individuals.
- Experiment 3 – Assess the effects of data format, density, and overall volume on decision making performed by small teams.
- Experiment 4 – Assess effectiveness of anti-bias training for small teams.
- Experiment 5 – Quantify information processing rates in rapid decision making for individuals.

Research Approach

Our research participants are recruited from campus ROTC units. They use a simulation of a hand-held computer that receives information over a data link. The information is in the form of a video clip, a photograph, a text message, and audio file, a computer-generated graph, or an icon on a map. These information items arrive in rapid succession in the 'inbox' and must be reviewed by the participant. They use the information to make decisions about potential incidents (such as a car bomb) that they are supposed to report. By design, the information they receive also contains a lot of false leads that should be rejected. We developed our patterns of false leads so they would tend to produce the types of decision errors found in previous research. The equipment they use is designed so that the state it is in tells us what information the user is processing, and we can tell how often a given piece of information is accessed, and whether the person found it meaningful.

Accomplishments

We have completed the first two major experiments and four small-scale pilot studies. In our first experiment, we investigated characteristic errors that occur as individuals make decisions rapidly. Specifically, we studied six characteristic errors reported in other decision making research to determine whether those errors occur in rapid decision making, and if so, to what extent. In our second experiment we assessed the potential effectiveness of anti-bias training to help reduce the occurrence of those characteristic errors. Our first small-scale study helped us refine the information presentation methods and to set the pace of information presentation so that subjects would have just enough time to process all the information and to make rapid decisions. Our second small-scale study helped us develop the division of responsibilities for a three-person team and structure the tasks the team members will perform. Our third small-scale study helped us set the pace of information presentation to teams and to refine training techniques for teams. Our fourth small-scale study helped refine the conditions for finding an upper limit for information processing during rapid decision making.

Our findings so far show that people can do a fairly good job at making these decisions rapidly. They are funding about 70% or more of the incidents they should report and are making reports on only about 30% of the false leads. The anti-bias training used in Experiment 2 showed some advantage, and we learned some ways to improve that training.

Contributions to Basic Research

The current work advances basic research in the areas of naturalistic decision making, team decision making, and in training to improve decision making. Previous research has identified characteristic errors (sometimes called biases) that humans commit when making decisions based on incomplete or conflicting information. Many of these biases seem to arise from unconscious strategies that reduce the effort required to process information, thereby allowing quick decisions to be made. Our research is examining whether these same types (or perhaps different types) of errors occur when an individual or small team is processing large volumes of information very rapidly. We are also investigating whether the same cognitive processes that produce the biases in the first place could be used to help counter the bias through

training. Specifically, we are studying whether individuals can learn to recognize the patterns of information that tend to produce errors.

Potential Army/Military Applications

The applications of this research for the Army are related to training individuals and small groups to assess information received in the field and to make rapid decisions based on that information. While in the field, an Army Unit of Action may receive information over a data link and download it to a hand-held computer, or through normal voice communications over the radio. Specific techniques that might be trained include spotting the 'markers' of a situation that tend to produce a decision error, and the specific countermeasures to take once the markers are spotted.

Future Plans

During the next year we plan to complete all remaining experiments. Experiments 3 and 5 are proceeding in parallel. In Experiment 3, we are investigating small teams (teams of three individuals) who are working together to rapidly process information and make decisions. In Experiment 4, we will study training techniques for small teams. In Experiment 5, volunteers who participated in Experiment 2 continue to perform rapid decision making tasks as we try to find an upper limit on the rate of information processing in this type of task.

Training for Efficient, Durable, and Flexible Performance in The Military

Problem(s)/Research Question(s) – This project aims to test and develop principles of training that promote efficient learning, durable memory, and flexible transfer performance.

Technical Barrier(s) – Learning, memory, and transfer performance are not always highly positively correlated; for example, rapid learning often leads to weak long-term retention. There is, thus, a technical barrier for finding conditions that simultaneously optimize all three aspects of training.

Significance/Impact for Basic Research – The experiments conducted as a part of this project should produce data that will support the development of a general theory of training encompassing learning efficiency, memory durability, and tranfer flexibility.

Potential Transitions – Knowledge gained in this basic research may be usefully employed in the following ARI applied programs (among others):
- Virtual Intelligent Training for Objective Force Warriors (WP 294)
- FUTURE-TRAIN: Techniques and Tools for C4ISR Training of Future Brigade (WP 211)
- Future Force Warrior Training (WP 215)
- VICTOR: Virtual Individual and Collective Training for Objective Force Warrior (WP 233)
- Training for Interactive Distributed Environments (WP 214)
- Simulation-focused Collective Aircrew Training (WP 231)

Overview

On the basis of earlier research, we were able to develop a set of training principles that optimize the efficiency and durability of trained performance. But we have also discovered that conditions that lead to durability often and perhaps always, lead to limited flexibility or adaptivity. In fact, in our most recent research, we have found that training has little or no benefit if there are discernable differences between the training and testing situations in the background or context, even if there are no changes made in the primary task requirements. The focus of this project is, thus, to develop training procedures for knowledge and skill that will survive primary task or background changes and, thereby, produce flexible, as well as efficient and durable, performance in military tasks.

Research Approach

The experiments in this project are divided into three major groups. Experiments in the first group are designed to understand how individuals can be trained to contend with an unpredictable flow of information often large in quantity, rapidly presented, and ambiguous. Experiments in the second group are aimed to identify training factors that promote adaptive and flexible performance in the field. The final group of experiments examines performance in dynamic and changing task environments. We conclude with an effort to create, still in the laboratory, a complex set of tasks similar to those encountered by a digitally proficient pilot operating a fully computerized cockpit, and not unlike those of the digitally proficient "land warrior" soldier of tomorrow. The major aim of this set of experiments is to determine the extent to which training principles, first established in a simpler laboratory task, generalize to performance under these more complex.

Accomplishments

In this summary, we focus on accomplishments in two of our series of experiments, both on information flow, which have helped us to confirm previously proposed training principles and to identify possible new principles.

The first series of experiments dealt with processing large amounts of information. Specifically, three experiments examined mediated learning of facts. In each experiment, subjects learned facts during a learning phase and were tested on all facts during a test phase. In Experiments 1 and 2, subjects learned facts about familiar individuals, unfamiliar individuals, or unfamiliar individuals associated with familiar individuals during an association phase. Using prior knowledge increased the amount learned and recalled even when prior knowledge played only a mediating role through association. In Experiment 3, subjects learned facts about unfamiliar persons or unfamiliar countries, with half the subjects in each group first learning associations between the unfamiliar items and familiar individuals (mediated) and half not (low). Using prior knowledge to mediate learning aided fact recognition during learning and testing (see Figure 1). However, this advantage during learning was greater when the new information was conceptually similar to the prior knowledge. The results argue against domain specificity for fact learning.

Figure 1
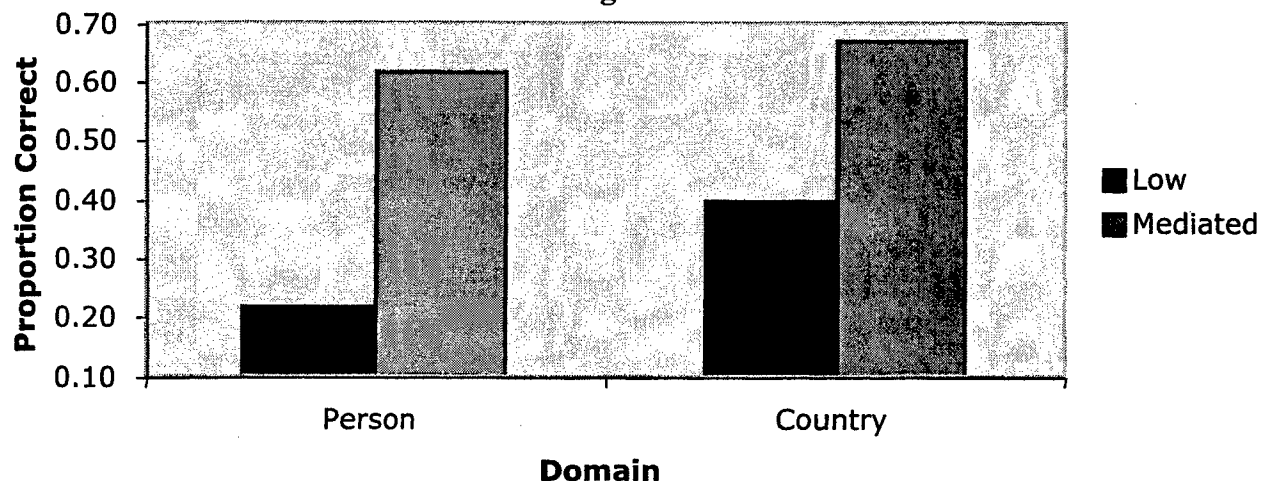
The second series of experiments dealt with rapid and prolonged processing of information. We published the first two experiments in this series (Healy, Kole, Buck-Gengler, & Bourne, 2004). A new experiment was completed this year. This experiment examined speed-accuracy tradeoffs in data entry and mental arithmetic tasks in order to test the cognitive antidote hypothesis, according to which adding cognitive complications to an otherwise routine task can mitigate the adverse effects of fatigue and/or boredom. There were four groups of subjects created by crossing task (data entry or mental multiplication) and feedback (bell for errors or no feedback). In each case, subjects received a stimulus and typed a four-digit response. The four-digit numbers used in the two tasks were the same. The stimuli on each trial consisted of a pair of single-digit multiplication problems (e.g., 3 x 4, 3 x 6) in the case of the mental multiplication task, but were the numbers to be typed (e.g., 1 # 2, 1 # 8) in the case of the data entry task. We found support for the hypothesized cognitive antidote hypothesis. For the data entry task, as found previously, accuracy declined across session halves and blocks within session halves, presumably because of fatigue and/or boredom. In contrast, for the more cognitively challenging mental arithmetic task, systematic improvements were found both in speed and in accuracy across session halves and blocks (see Figure 2). However, the improvement in accuracy across blocks was found only for the mental arithmetic conditions with feedback. The mental arithmetic conditions with no feedback led to stable performance, with no consistent change across blocks. This experiment demonstrates that adverse fatigue effects on accuracy can be offset by adding cognitive complexities to the task and/or by providing feedback on the correctness of the individual responses. Accuracy performance was optimized when these two antidotes were combined.

Figure 2
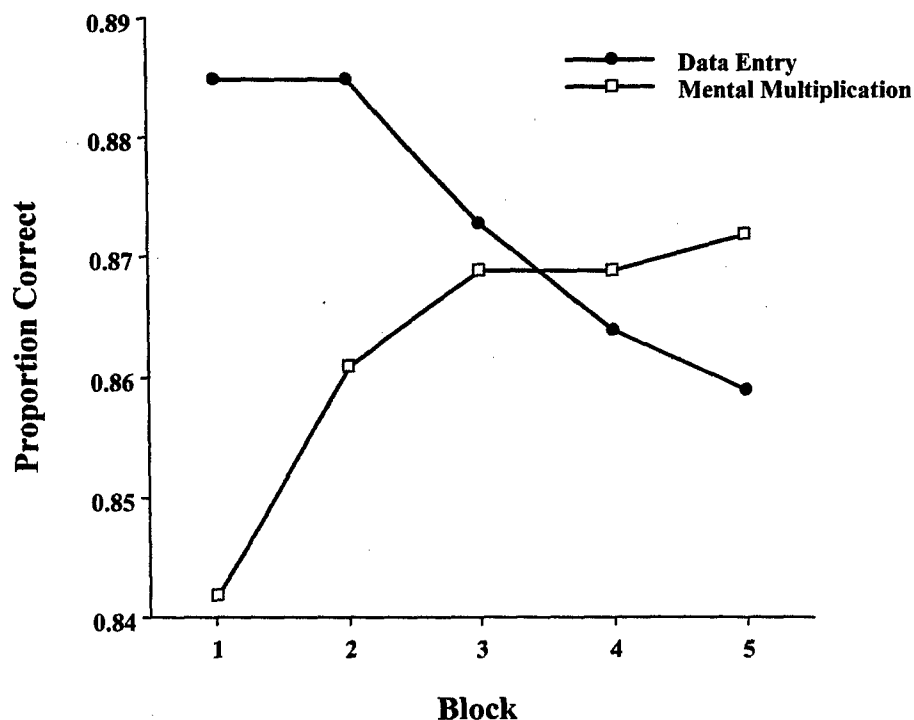
Contributions to Basic Science

We have proposed the following theoretical principles for optimizing training: principle of contextual interference, training difficulty hypothesis, depth of processing principle, procedural reinstatement principle, specificity of training principle, functional task principle, and strategic-use-of-knowledge principle. The primary purpose of our experiments is to collect data that allow us to accept or reject each of these training principles that we formulated on the basis of our earlier basic laboratory research and to develop and test new principles that are supported by these data. For example, our recent study of fatigue allowed us to confirm a cognitive antidote hypothesis, which could serve as a new training principle.

Potential Army/Military Applications

Our experiments could be used to drive applied research. To illustrate this potential symbiosis between basic and applied research, we give two brief examples. First, our research has demonstrated a high degree of specificity from training to subsequent application. These findings have crucial implications for military training because instructors often assume that teaching a primary task without extraneous secondary task requirements will benefit the learning process. However, our findings imply that to be effective, training must incorporate as many of the complete set of field task requirements as possible, including all secondary task requirements that might be imposed. In our research, we are testing the boundary conditions of our finding using a variety of primary and secondary tasks, and we are testing hypotheses concerning ways to overcome this severe specificity. Although the tasks used in our research are often components of military tasks and require digital proficiency, they are not the real military tasks currently being trained in the Army. We hope that applied research units are interested in testing whether the specificity of training principle we have developed would apply to such real tasks and whether the methods we hope to develop for overcoming this problem could be adapted to improve military training. To that end, we have had discussions with Stephen Goldberg (Chief, Simulator Systems Research Unit) about future collaborative research on the applicability of our training principles to simulator training. Second, military instructors often attempt to use procedures that make learning easier and speed up initial skill acquisition. However, our research demonstrates that, although introducing sources of interference into a task or increasing the difficulty of the task slows down initial skill acquisition, these variations ultimately lead to improvements in the durability and flexibility of the learned skill. In our research, we are testing this principle in a variety of task domains, and we are testing an extension of this hypothesis, namely whether the difficulty of a secondary task has a similar inhibiting effect on initial learning and facilitating effect on retention and transfer as does the difficulty of a primary task.

Future Plans

Our proposal was divided into three substantive sections, with each section further divided into three subsections: (a) dealing with information flow, (b) factors promoting adaptive and flexible performance, and (c) coping with dynamic environments and changing task demands. We gave a detailed description of at least one major experiment in each of these subsections. During the first year of the project, experiments were conducted on each of the three substantive sections; three major experiments were undertaken that year, one in each of the three sections. During the second year of the contract we completed eight new experiments. During Year 3, we plan to conduct five new experiments, and we also plan to write up and submit for publication

one or more manuscripts based on the work completed in the first two years of the contract. In addition, we hope to extend our discussions with Dr. Goldberg and initiate discussions with Dr. Pleban about possible collaborative applications of our research to military training. We also started to program a complex set of tasks simulating the battlefield situation faced by today's soldiers. When the complex environment is fully programmed, we plan to design and execute the first of several experiments examining the generalizability of previously established training principles using that simulation.

FOCUS: A Model of Sensemaking

Contract #: 1435-01-01-CT-31161   **Contract Dates:** 6/1/01-6/1/04
Institution: Klein Associates Inc.   **PI:** Gary Klein
                                                 Co-PI: Winston R. Sieck

Problem(s)/Research Question(s) – What are the cognitive processes people follow in order to make sense of a situation? What training interventions can be used to improve individuals' sensemaking performance?

Technical Barrier(s) – The concept of sensemaking (initially formulated by Weick, 1995) was not developed from a cognitive perspective. A detailed description of sensemaking mechanisms is necessary in order to develop effective training and system interventions to support this cognitive function.

Significance/Impact for Basic Research – Understanding the cognitive processes involved in sensemaking contributes to basic science by describing this critical cognitive process and exploring ways to improve performance of this process through training.

Potential Transitions – Knowledge gained in this basic research may be usefully employed in:
- Future Force Warrior Training (WP 215).
- LEADERSHIP: Developing leaders in a Changing Army (WP 103).
- VICTOR: Virtual Individual and Collective Training for Future Warriors (WP 233).
- SIMAIR: Simulation-focused Collective Aircrew Training (WP 231).
- Accelerating Leader Development (WP 269).

Overview

Army leaders are often placed in situations that are either unfamiliar or filled with uncertainty. In order to be successful, Army leaders must be able to quickly and efficiently make sense out of rapidly changing situations. Without an understanding of the situation, they cannot take appropriate actions. Developing this understanding is difficult, especially when one is faced with conflicting or limited information.

Sensemaking is the process by which people develop their understanding in the face of surprising information. Experts have demonstrated the ability to do this with almost uncanny skill as they put together pieces of a puzzle that novices do not even see. Research on the topic has helped define situation awareness and its different levels. However, we still do not understand the process by which experts make sense of situations and how this sensemaking ability develops over time. Understanding sensemaking is critical if the Army wants to train and develop this skill in its future leaders. The problem is that no one fully understands the process of sensemaking. The purpose of this project is to examine the process of sensemaking, how it develops, and ways to improve sensemaking through training interventions.

Research Approach

This study was conducted over the course of three years.

Year 1 research focused on testing an initial model of sensemaking—the Framework for Observing, Comprehending, and Understanding Situations (FOCUS). Experienced and novice Information Operations (IO) officers completed a series of scenarios designed to challenge the participants' sensemaking. Participant comments during the scenarios were categorized and coded based on the types of inferences, speculations, and explanations made. In addition, researchers collected real-life incidents of navigational sensemaking in which participants became lost while driving and had to reorient themselves. Based on the results from the scenarios and incidents, it became evident that the initial FOCUS model did not fully represent the sensemaking process. The research team then developed the Data/Frame Model of Sensemaking (see Figure 1).

In Year 2, new Cognitive Task Analysis data collection methods were developed and used to further test the model. Cognitive Task Analysis is a series of methods and tools used to gain in-depth access to the mental processes that underlie performance of tasks. The researchers used these methods during interviews with IO officers to elicit and explore incidents in which the participants faced challenges to sensemaking. Based on these data, the Data/Frame Model was further refined and extended to include six distinct sensemaking functions: elaborating the frame, questioning the frame, preserving the frame, comparing frames, seeking a frame, and reframing. In addition, a number of assertions regarding the nature of sensemaking were proposed.

Efforts in Year 3 were devoted to accomplishing two aims. First, tests of critical assumptions of the model were sought. Second, a deeper understanding of expert/novice differences was sought in order to further expand on the training recommendations offered in Year 2. Researchers recoded and reanalyzed the IO officer comments from Year 1 to further examine expert/novice differences. Additional interviews were conducted with IO officers at 1st IO Command in which participants responded to a series of scenarios. These data were coded and analyzed for specific expert/novice differences.

Accomplishments

This research effort has produced several significant findings about the nature of sensemaking. First, we have defined sensemaking as the process of fitting data into a frame, and fitting a frame around the data. People will try to make sense of data inputs they receive by finding or constructing a story to account for the data. At the same time, their repertoire of stories will affect which data elements they consider and how they will interpret these data. Thus, the frame and the data work in concert to generate an explanation. We also suggest that data elements are not perfect representations of the world, but are constructed. They are sampled from the available information and defined in terms of the available frames. They are abstractions from the environment, and therefore distortions of reality. We assert that no more than three or four of the key data elements serve as anchors, which elicit the initial frame used to sample for more data elements.

In our Data/Frame Model of Sensemaking (Klein et al., 2003), we have differentiated and described six activities, or building blocks, of sensemaking: elaborating the frame, questioning the frame, preserving the frame, comparing frames, seeking a frame, and reframing. Further, we have identified two sensemaking cycles that encompass these activities: the assimilation and accommodation cycles, corresponding to the usage suggested by Piaget (1954). During

assimilation, the person fits data and information into the frame or cognitive map. During accommodation, the person alters the frame to fit the data.
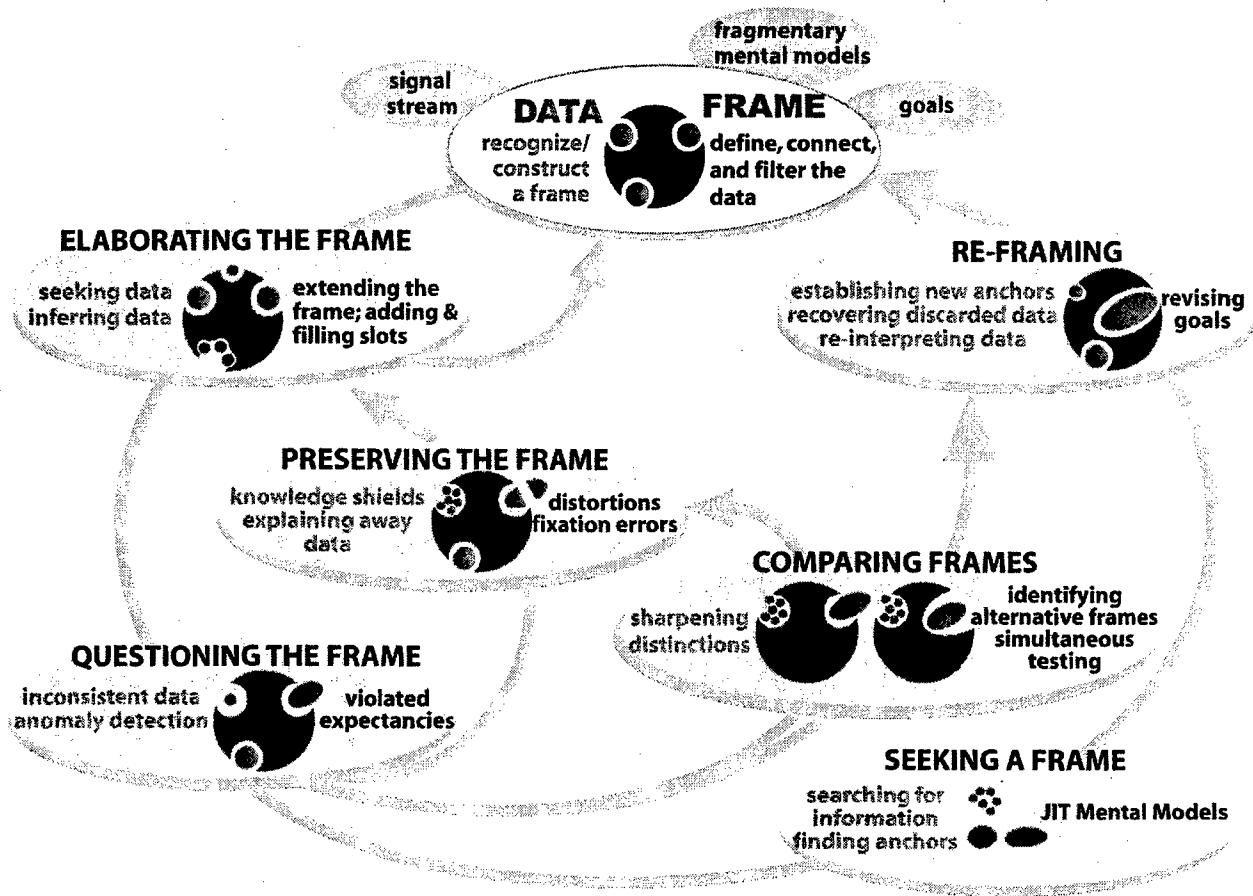
Figure 1. Data/Frame Model of Sensemaking.

We also extended our discussion of quasi-logical reasoning (Klein, Phillips, Battaglia, Wiggins, & Ross, 2002) into the notion of "possibility theory," as opposed to probability theory and deductive inferences. The reasoning we observed in our incident data rarely employed deductive logic. Instead, it was aimed at employing inferences in order to identify anchors that could be used in sensemaking. We assert that quasi-logical reasoning and possibility theory are strengths in the process of sensemaking.

Consistent with prior research (Barrows, Feightner, Neufeld, & Norman, 1978; Chase & Simon, 1973; Elstein, 1989), our findings also suggest that expert/novice differences in sensemaking performance are not due to superior reasoning and inferencing strategies on the part of the expert, but rather to the quality of the frame that is brought to bear. Experts have more factual knowledge about their domain, they have built up more experiences, and they have more knowledge as to cause and effect relationships. They are more likely to generate an accurate explanation of the situation than novices because their frame enables them to select the right data from the environment, interpret them more accurately, and see more pertinent patterns and connections in the data stream.

Our research also suggests that developing a comprehensive mental model for a complex, open system is unrealistic. Instead most people, and even most experts, rely on fragments of

local cause-effect connections, rules of thumb, patterns of cues, and other linkages and relationships between cues and information to guide the sensemaking process (and indeed other high-level cognitive processes). We believe that a set of fragmentary mental models contribute to the frame that is constructed by the sensemaker, therefore guiding the selection and interpretation of data.

We have elaborated the model such that it can be used to generate testable hypotheses—including non-trivial and non-obvious hypotheses—and have presented several hypotheses as starting points for model testing.

We found that IO experts exhibit a stronger delineation between sensemaking and decision-making processes. Experts attempt to first clearly understand the situation they face, and then proceed to formulate courses of action and other decision-making activities. Furthermore, IO experts are much more likely than others to formulate high-quality questions geared towards understanding anomalous evidence. The kinds of questions IO experts asked varied in terms of generality.

Contributions to Basic Research

The sensemaking model developed in this effort describes a higher-order cognitive process that is a critical component of decision-making success in naturalistic environments. Sensemaking drives the ability to comprehend the meaning and relevance of large amounts of ambiguous data. This ability separates the individual who is on top of the situation, and able to form expectancies to guide smooth performance, from the individual who is continually surprised and confused and acts hesitantly in responding to the crisis of the moment. This effort contributes to basic science by describing this critical cognitive process and exploring ways to improve performance of this process through training.

Potential Army/Military Applications

An understanding of sensemaking is relevant to Army efforts to design various types of decision support systems. By describing how humans actually use information to develop and revise interpretations of a situation, we can develop command and control and other technologies that work in concert with the human and support his/her natural process for filtering information and building and maintaining situation awareness. Our findings-to-date on the nature of the sensemaking process offer initial guidance on several important issues in the field of decision support, such as the effect of information rate on skilled performance and possible evaluation metrics for systems intended to bolster sensemaking activities.

Defining the process of sensemaking is also relevant to Army training needs. Our findings illustrate areas in which sensemaking can break down and even fail. Training programs can be structured to enable practice and feedback in key sensemaking activities. Our findings also highlight areas of expert/novice differences. Training scenarios can be structured to deliberately build sensemaking expertise in non-experts through the development of mental models, fragmentary mental models, and anticipatory thinking skills.

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Final Summary

This research effort explored sensemaking—the process people use to make sense of situations. This research included model development, testing, and implications for training that can help Army personnel to build and recover their understanding of situations more efficiently.

This project resulted in the development of the Data/Frame Model of Sensemaking, which details critical features of sensemaking processes. This Data/Frame Model proposes that data and frames (theories) result in understanding via a highly interactive process. Primary sensemaking activities include frame elaboration, questioning, comparison, preservation, seeking, as well as reframing. Early research efforts developed the Data/Frame Model and identified the components and linkages that describe how individuals engage in sensemaking. Later efforts focused on expert and novice differences in frame questioning, and issues regarding whether expert questioning strategies could be identified and taught.

The ability of commanders at all levels to quickly and efficiently come to understand situations is of critical importance to the success of modern military missions. The results of this research effort are currently being applied in several areas. First, the Data/Frame Model is informing the development of information technology that aids sensemaking. The focus of a Phase I project has been to provide military system designers with a methodology and support tools for capturing and leveraging sensemaking requirements. Currently, these support tools do not exist. The Phase I effort successfully developed and piloted a sensemaking methodology that is rooted in the Data/Frame Model. Second, the model and empirical results are also proving useful to the development of cognitive metrics for intelligence analysis and related domains. Finally, the insights that have been gleaned from the initial basic research into expert and novice differences in sensemaking strategies should prove useful towards the development of training methods and materials for promoting sensemaking skills across domains.

Factors Influencing the Design and Conduct
Of Effective Technology-Delivered Instruction

Contract #: DASW01-04-K-0002
Institution: The University of Tulsa
        Illinois Institute of Technology

Contract Dates: 03/01/04-02/28/06
PI: Kurt Kraiger
Co-PI: Annette Towler (IIT)
Liaisons: Scott Graham, IFRU;
        Jim Belanich, RACO

Problem(s)/Research Question(s) - Do seductive details (i.e., entertaining and interesting information that is only tangential to the main theme of the topic) and on-screen text hinder learning of declarative and procedural knowledge in a computer-based training environment? Given the seductive details effect, can good instructional design principles reverse the effect? Does the impact of seductive details on learning depend on trainees' learning styles?

Technical Barrier(s) - In order to test instructional design principles, it is first necessary to establish a seductive details effect for training on real-world tasks. Previous research has focused exclusively on declarative knowledge and the majority of the studies have been conducted by a single researcher, Richard Mayer, and his colleagues. In addition, previous research has not examined whether trainees' learning styles affects the extent to which seductive details impair learning.

Significance/Impact for Basic Research - The results will allow us to assess the extent to which including seductive details in training impairs both trainees' ability to recall the facts and principles taught in training and their ability to perform the skills that were taught. In the long-term, this research will enable the military to design more effective computer-based training.

Potential Transitions - The knowledge acquired from this basic research can be used to test a variety of instructional design principles. In the past, most design principles have been tested only in comparison to a "no-treatment" or "placebo" effect. Once we establish the seductive details effect, we can test the effectiveness on a variety of instructional design principles by examining their ability to "undo" the seductive detail effect.

Overview

One common strategy for enhancing any type of training is to make the content as interesting as possible. Intuitively, these strategies should increase intrinsic motivation in learners, resulting in greater appreciation for the material and greater persistence in learning environments. Obviously, interesting information that is central to the main topic is useful and can facilitate trainees' learning. However, trainers or instructional designers tend to include interesting information that is unrelated to the central theme to spice up mundane information. This phenomenon is called the "seductive details effect" and refers to essentially "highly interesting and entertaining information that is only tangentially related to the topic but is irrelevant to the author's intended theme" (Harp & Mayer, 1998, p. 1). Instructional material can be seductive through inclusion of illustrations or text that is interesting and entertaining but tangential to the topic (e.g., adding a picture of a professional football team to a training module on teamwork).

Although one could argue that the inclusion of seductive details increases trainees' emotional interest in the topic, there is evidence suggesting that the inclusion of this material disrupts trainees' concentration on the main themes of the material (Harp & Mayer, 1998; Mayer, Heiser, & Lonn, 2001). Thus, trainees learn less in courses where seductive details are included along with the presentation of material relevant to the topic of the course.

However, previous research on the seductive details effect has focused exclusively on declarative knowledge and has primarily been conducted by a single researcher, Richard Mayer. The goal of the initial study is to assess the impact of seductive details and on-screen text on trainee's ability to perform the skills taught in a computer-based training course. This will allow us to assess the impact of seductive details on procedural knowledge. Based on previous research, it was hypothesized that trainees would learn less when seductive details were included in training than when training did not include seductive details.

Research Approach

Undergraduates participate in a 10 minute computer-based course on how to use Excel. The course demonstrates several functions in Excel that could be used to select a city to live in based on the city's average rainfall and temperature. Participants are randomly assigned to one of four experimental conditions: 1) training includes both seductive details and on-screen text, 2) training includes seductive details but not on-screen text, 3) training includes on-screen text but not seductive details, 4) training did not include seductive details or on-screen text. On-screen text summarizes key points covered in training, while seductive details included interesting facts about the data used in training such as "Tree crickets are called the poor man's thermometer because temperature directly affects their rate of activity. Listen for a cricket and count the number of chirps it makes in fifteen seconds. Add 37. The sum will be the Fahrenheit temperature (almost exactly!)."

After viewing the training video, trainees complete a multiple choice test on their ability to recall the facts taught in training and are asked to perform the skills that were demonstrated in the video. Trainees then fill out several measures for half an hour to distract them from thinking about the training course including an assessment of four learning styles: auditory (i.e., learning from listening and discussing the material), visual (i.e., learning from demonstration and visual aids), tactile (i.e., learning from performing the task), and reading (i.e., learning from reading and writing). Finally, trainees are given one more test to assess their ability to perform the tasks taught in training. This performance measure is used to assess transfer.

Accomplishments

Currently, data from 45 participants have been collected from undergraduates at the University of Tulsa. Data from at least 40 participants at the Illinois Institute of technology will be collected by December 2004. The results below reflect the analyses performed on the first 45 participants. The two datasets will be merged in December 2004 to assess the effect of seductive details on learning.

Seductive details did not have a large impact on trainees' ability to perform the skills taught in training immediately after viewing the video or on the transfer task. The average level

of performance immediately following training and on the transfer task was slightly better for the seductive details group than the no seductive details group (See Table 1). Thus, scores on the performance tasks failed to support the hypothesis. However, seductive details did affect trainees' scores on the multiple choice test in the hypothesized direction. The average level of performance for the seductive details group was slightly worse than the average level of performance of the no seductive details group.

Table 1. Means and standard deviations for scores on the three posttests.

	Performance task following training		Transfer task		Multiple choice test	
	Mean	SD	Mean	SD	Mean	SD
Seductive details						
No	.66	.20	.65	.18	.72	.15
Yes	.68	.24	.71	.20	.66	.20
On-screen text						
No	.63	.24	.65	.18	.67	.19
Yes	.71	.21	.72	.20	.71	.18

On-screen text improved trainees' ability to perform the skills taught in training immediately after viewing the video and on the transfer task and increased their scores on the multiple choice exam (See Table 1).

Seductive details interacted with trainees previous experience with Excel when predicting scores on the performance test following training (i.e., the impact of seductive details on learning depends on trainees' familiarity with Excel) (See Figure 1). In the no seductive details condition, trainees who were unfamiliar with Excel outperformed trainees who were familiar with Excel. In the seductive details condition, trainees who were familiar with Excel performed slightly better than trainees who were unfamiliar with Excel.

Seductive details interacted with trainees' auditory learning style when predicting scores on the performance test following training (See Figure 2). Trainees in the seductive details condition performed poorly on the performance test following training, regardless of whether they had an auditory learning style. In the no seductive details, trainees with an auditory learning style outperformed those without an auditory learning style.

Figure 1
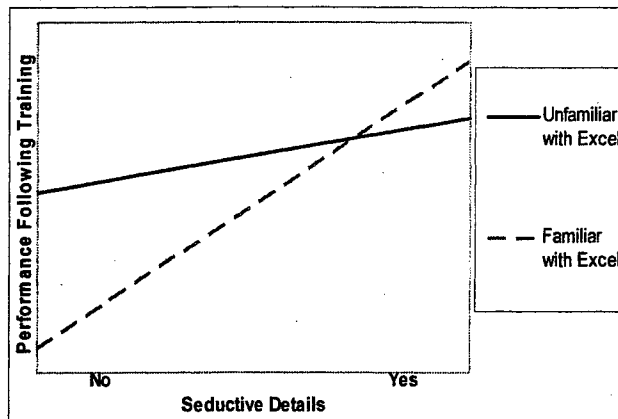
Figure 2
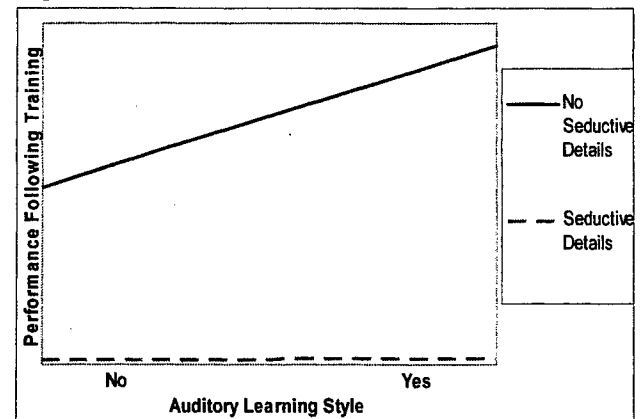
Seductive details interacted with trainees' tactile learning style when predicting scores on the multiple choice and performance tests following training (See Figures 3 & 4). Trainees in the seductive details condition performed poorly on the multiple choice and performance tests following training, regardless of whether they had a tactile learning style. In the no seductive details, trainees with a tactile learning style outperformed those without a tactile learning style.

Figure 3
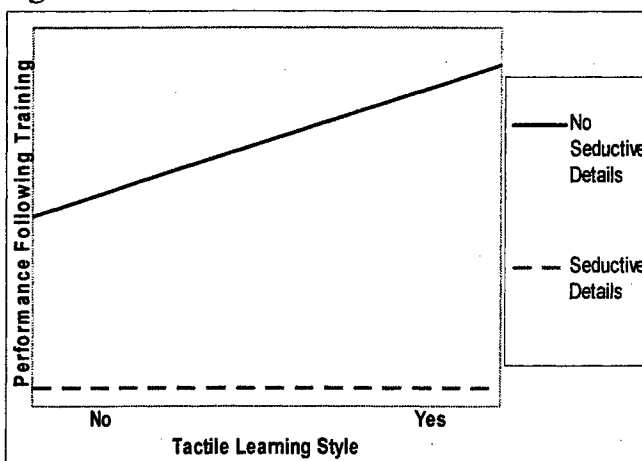
Figure 4
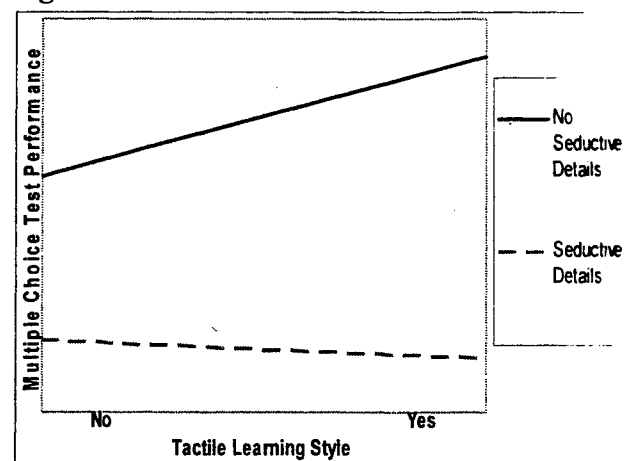
Contributions to Basic Science

Results to date suggest that seductive detail effects are not as straightforward as previously thought. For example, our results show that seductive details have a greater effect on declarative knowledge than procedural knowledge, and that the impact of seductive details may be moderated by trainees' learning styles. More specifically, the results indicate: 1) seductive details did not have a large impact on trainees' ability to perform the skills taught in training 2) seductive details did impair performance on a multiple choice test on the same material 3) the impact of seductive details on learning outcomes depends on trainees' learning styles.

However, the current results should be interpreted in conjunction with previous research. Mayer and others demonstrated seductive details impair trainees' ability to recall the information taught in training and to produce creative solutions to a transfer task in training on lightening formation

(Mayer, Heiser, & Lonn, 2001; Harp & Mayer. 1997; 1998). The discrepancy between Mayer's findings and the current results may indicate: 1) seductive details impair the ability to recall declarative knowledge but not procedural knowledge 2) the ability of the researcher to detect the seductive details effect depends on the test format 3) there are differences across researchers in their ability to detect the seductive details effect.

Potential Army/Military Applications

The initial study is intended to create a baseline effect for later testing of instructional design principles, and it is these later studies that will have the greatest application to military training practices. However, or partial replication of the seductive detail effect in a computer-based training environment suggests that instructional designers and trainers in the military should be cautious about including in training content too many interesting examples that are irrelevant to the main points, particularly when the training focuses on the acquisition of declarative knowledge.

Future Plans

The goal of the next several research experiments will be to:
1. Test whether discrepancies between Mayer's findings and the current results are due to the test format or type of knowledge taught in training (i.e., declarative or procedural). A computer-based Excel course will be developed to teach several skills (i.e., procedural knowledge) and several facts about Excel (i.e., declarative knowledge). Trainees will then complete a multiple choice and performance test on both the declarative knowledge and procedural knowledge components of training.
2. Replicate Mayer's research (Harp & Mayer, 1997). Students will be given a booklet to review on lightening formation to assess the impact of seductive details on learning outcomes. This will allow us to assess whether the discrepancy between Mayer's results and the current findings are due to differences across researchers.
3. Test whether seductive details have a deleterious effect depending on whether they are dependent on instructional content or not. This study originates from Scraw's belief that seductive details represent a heterogeneous class of information with participants devoting more processing time to context-dependent seductive details than to context-independent seductive details. We plan to replicate Schraw's study using a skills-based task – learning how to perform Mailmerge in Microsoft Word.
4. Design a training intervention around the use of advanced organizers to reduce the seductive details effect.
5. Validate a measure of learning styles to be used as a covariate in future studies.

Understanding Aspects of Individual and Collaborative Skill Acquisition in Face-To-Face and Distance Training Situations

Problem(s)/Research Question(s) – How do teams learn at a distance? How does changing the context between training and test affect performance? What kind of training can we provide to improve that transfer between contexts?

Technical Barrier(s) – Cognitive issues for team/group training is a relatively recent topic of study. Teams of more than two individuals are difficult to acquire and sustain for multi-day experiments. Improved technology allows for both more sophisticated studies and better measurement tools; however, this also means relying on outside vendors (to supply the advance software & programming support) and also on-site technical support.

Significance/Impact for Basic Research – Through this research, we will have a better understanding of the factors that affect team learning across contexts (i.e., what affect interacting face-to-face versus communicating via technology, what affect the context of complex software plays on this interaction).

Potential Transitions – Knowledge gained in this basic research may be usefully employed in:
- Training for Interactive Distributed Environments (WP 214).
- Other training programs.

Overview

The purpose of this research is to examine: a) whether teams training together in the same location (co-located) will train more quickly and efficiently than teams who are not in the same location (distributed); b) whether testing in the same situation/context (co-located to co-located and distributed to distributed) is better than training in different situations/contexts (co-located to distributed and distributed to co-located); c) whether we can develop training to improve the transfer between contexts; and d) whether the training will improve learning.

Research Approach

This research asked teams of three individuals to learn a complex task and then use that knowledge to work together to solve some new tasks. Originally, for the tasks, individuals were asked to learn how to operate an Unmanned Air Vehicle (UAV) where the three individuals, each with different jobs, must fly a UAV to various locations and take pictures of specific targets. After an initial study, the new focus shifted to peacekeeping missions where three individuals manage different resources in Support and Stability Operations (SASO). Both of these contexts are simulated in the laboratory and training/testing is performed using the following methodology. First individuals learn the complex task either together (face-to-face, co-located) or apart (distance, distributed). Then a new, equally complex task is chosen and the individuals are asked to perform the new task. They are either asked to stay in the same context

or change to the other context. Initially, for the UAV task, co-located context, the computer consoles were in a semi-circle that allowed individuals to speak over-the-shoulder to each other; for the distance context, the individuals were separated by a screen, with one in another room. For the SASO task, co-located, individuals are facing computes in a circular configuration which allows them to talk to each other easily; for the distance context, the individuals are in completely separate rooms with sound material on the walls. The new technology allows for smaller, lighter computer equipment that can be easily moved to different rooms and communication occurs through light headsets.

Accomplishments

In the Spring and Fall 2002, the first research on co-located/distance team training and transfer was performed in the UAV CERTT lab. Performance results are shown below. Although all teams received the same initial (declarative) knowledge training, distance teams outperformed co-located teams throughout the initial hands-on training sessions and after transfer. The distance teams reached a plateau but this was probably due to a lack of feedback. After transfer, all teams experienced a decrement in performance (similar to Singley & Anderson, 1989) but the distance teams (i.e., those who trained at a distance and either stayed in the same distance condition or transferred to a co-located condition) showed a greater improvement for the two training missions after transfer. These results may have been due to the small numbers of teams or the experimental setup in the UAV lab which may have suppressed co-located performance.
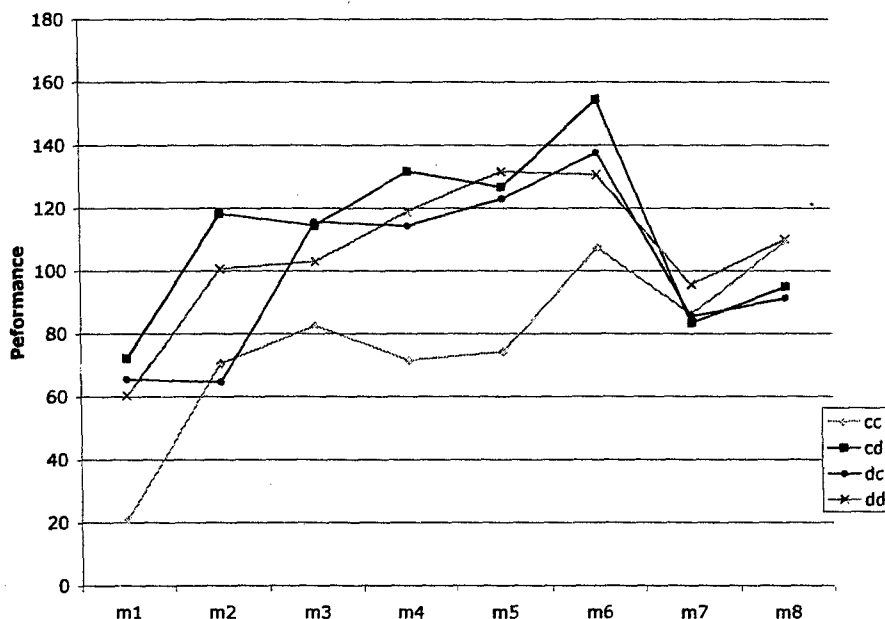
Figure 1. Results from Experiment 1.
Note change in context occurs at Mission 7. CC= co-located; DD= distributed; CD = co-located to distributed; DC = distributed to co-located.

In 2003 we developed the SASO lab and tested the software both among the graduate student assistants and with practice teams. We were able to get necessary changes to the SASO

software and to debug that software, install video and audio recording, re-configure a lab space to house the hardware and train assistants on the task. From Spring 2004 and continuing through this fall, we have been replicating the study in the SASO lab. The main differences in physical context were described above; however, we added a communication training component. We have run 50 teams so far and have a goal for this first experiment of 60 teams. (We increased the number in order to test the technology of push-to-talk versus no push-to-talk.) Preliminary results for some of the teams are shown in Figure 2. So far the results using only the no push-to-talk data follow the same pattern as the UAV study but do not show as clear a distance training advantage. In the spring, we intend to replicate the study again in the SASO lab using a change in context in the actual SASO software (described below). In this way, we can see whether the change in the technology has a bigger effect than a change in the physical context.
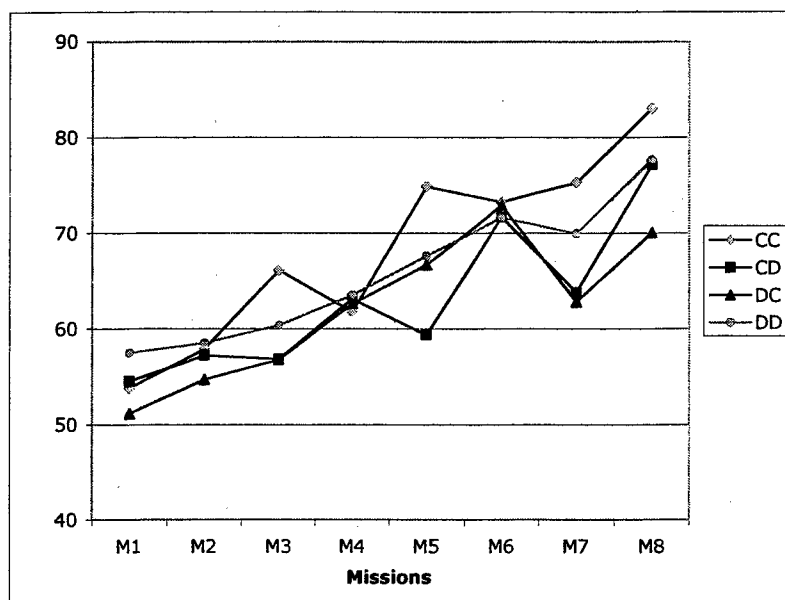
Figure 2. Results to date (9/1/2004). Only 34 teams included.

Contributions to Basic Research

In recent years, the advancement of military technology has resulted in highly complex skills that need to be acquired and maintained to use that technology (Barry & Runyan, 1995). Consequently, the demand for ongoing innovations including distance training has increased. Distance training has been show to be extremely cost effective and has produced similar learning outcomes. Although extensive research on distance learning exists, few studies have focused on group (collaborative) distance training delivered by internet/web-based technologies.

A parallel development has occurred in the area of team training. Even though group (collaborative) learning has been the focus of many studies (Slavin, 1996) and progress has been made on knowledge measurement at the individual level, the measurement of team knowledge, and team cognition in general, is still in its infancy (Cooke, Salas, Cannon-Bowers & Stout, 2000). Thus, research on how to improve team distance learning can contribute significantly to the field in several areas including distance education and across context team transfer.

Interest in distance education has increased due to a concerted effort on the part of public educational institutions to reach new populations of students who might not otherwise be able to attend. With advancements in technology, this has been possible (particularly in the use of web-based training). On the other hand, few controlled studies exist to determine what is truly beneficial.

Controlled studies for team distance training could also contribute to the transfer literature generally. Research has been performed on individual transfer (Singley & Anderson). Although specifications for transfer are delineated, research on context effects has not been as conclusive (see McDaniel, Anderson, Einstein & O'Halloran, 1989 or Wickens, 1987). The current research project is focused upon describing the effects of a particular physical context change on team performance (with a focus on cognitive skills but also some measurement of social skills).

Potential Army/Military Applications

The applications to the military are expected to be in principles for distance training and transfer (changing from one situation to another) situations. Specifically, these studies are designed to determine what conditions promote distance training and transfer and what training is needed to improve team and distance transfer. In addition, within the studies, various assessment measures will be used that will focus on individual and team cognitive and social (social-cultural) skill development.

Current Research and Future Plans

Currently, we are running teams to complete the first study. For the second study, we would like to identify places where training could be improved and provide that additional training. In addition, we will examine a context change in software. Specifically, the current SASO software focuses on Bosnia. We would like to switch the surface features of the Bosnia software to reflect Darfur. A graduate student research assistant is researching Darfur and we will be developing a whole suite of training software for that region. In the second study, participants will train on either the Bosnia or Darfur software and during the transfer/test portion, they will transfer to the other region. The basic transfer between physical contexts will remain the same as described previously with this added dimension. We started negotiating with Aptima about what needs to be changed and we hope that they will be able to deliver the software by the early spring. We anticipate being done running teams for the second study by the end of summer or early fall and completing the analysis and report in Fall 2005.

Exploring the Interaction of Implicit and Explicit Processes to Facilitate Individual Skill Learning

Contract #: DASW01-00-K-0012
Institution: Rensselaer Polytechnic Institute

Contract dates: 9/00-8/04
PI: Ron Sun
Co-PI: Robert Mathews

Research Question(s) – How can learning from experience and learning from explicit thinking (explicit mental models) be integrated to enhance expertise?

Technical Barrier(s) – The interaction of these two types of knowledge is not yet well understood, more experimental data are needed, and complex patterns of data need better explanation.

Significance/Impact for Basic Research - Understanding how implicitly acquired knowledge from experience interacts with explicitly acquired knowledge (mental models) of a task will lead to a better understanding and better computational theory/models of human learning.

Potential transitions – Knowledge gained in this basic research may be usefully employed in:

- Future Force Warrior Training program (WP 215) - Training programs that facilitate rapid accurate decision-making.
- Various training programs: VICTOR: Virtual Individual and Collective Training for Future Warriors (WP 233); SIMAIR: Simulation-Focused Collective Aircrew Training (WP 231), and Training for Interactive Distributed Environments (WP 214) - How implicit and explicit training interact and affect skill learning.

Overview

Any high level of skill depends on both conceptual and subconceptual (experiential) knowledge. However, experts are often only aware of their explicit conceptual knowledge. Experientially acquired subconceptual (implicit) knowledge is more akin to pattern recognition. For example, when you recognize a friend's face, you instantly know who the person is, but you may not be aware of what cues or features are being used to recognize him/her. This lack of awareness of essential implicit experiential knowledge creates serious challenges for training and learning in the military as well as civilian context. The overall goal is to better understand the interaction of the two types of knowledge. The specific purposes of this research program are (1) to experimentally investigate the interaction between knowledge gained from hands-on experiential (implicit) learning and explicitly formulated conceptual knowledge in the development of skills and expertise, (2) to clarify how conscious reflection and resulting conceptual knowledge can be employed to enhance, rather than interfere with, experiential learning, (3) to discover the optimal mix of experiential and conceptual training over a range of skill acquisition from early novice to a high level of expertise, and (4) to develop computational models and theories of human skill learning that emphasize the interaction of these two types of learning, which may be of use in structuring and optimizing training, on the basis of our experimental and simulation results.

Research Approach

We will conduct a series of laboratory experiments in two different task domains: artificial grammar learning and process control. Both tasks, using college students as participants, involve learning a system that operates according to complex, difficult-to-learn rules. In the artificial grammar experiments, participants learn to spot poison can labels on a computer simulation of a starship that has been invaded by enemy agents. Identification of poison food labels requires learning to identify sequences of letters generated by a finite state grammar. Training for this task might include memorizing a diagram of the grammar (explicit training), memorizing cases (implicit training), or an integrated training that involves tracing cases through the grammar diagram.

The process control task involves learning to control the temperature of a simulated nuclear reactor by controlling the number of fuel pellets. The appropriate number of pellets to use depends on the current temperature of the reactor sometimes creating counterintuitive situations where increasing the number of fuel pellets decreases temperature. Also, a noise element is included in the formula making the results somewhat uncertain over trials. This task is known to be difficult to learn and difficult to explain how one accomplishes the task when it is learned.

Accomplishments

In the artificial grammar experiments, we found slow but accurate responding among participants when explicitly trained and fast but less accurate responding when implicitly trained. Integrating or mixing types of training generally produced more accurate performance than implicit training and faster performance than strict explicit training. Simulations using CLARION have confirmed these findings. One interesting finding was that when exposed to both types of training, participants showed a tendency to prefer using the implicit mode. In the case of strict explicit followed by implicit training (a pattern that is common in many training situations, e.g., explicit schooling followed by field training) we noticed a loss of accuracy as learners shifted toward the implicit mode. We think training can be accelerated and this post-training drop eliminated by using the explicit conceptual knowledge to prime rather than compete with implicit learning. In a final experiment we were able to obtain the best of both worlds—fast and accurate responding—by incorporating an animated version of a diagram of the grammar that indicated how current exemplars fit into the model during practice.

The process control results show that detailed reflection during task performance interferes with learning. Thus, it is not always advantageous to combine completely explicit and implicit training. However, reflection following short periods of practice can be beneficial, especially when hints are provided about how to reflect. Analyses of these results suggest that reflecting on instances where one responded correctly can be beneficial to learning. However, more general reflecting on the nature of the task or general rules controlling reactor temperature do not seem beneficial. Simulations using CLARION are also producing interesting hypotheses. Unlike the artificial grammar task, there are large individual differences in the ability to learn this task. Potentially, we can facilitate learning in these "failing" participants by instructing them on what to focus on when they reflect. A simple hint consisting of providing three correct responses to particular task situations greatly increased learning.

In the process, the cognitive architecture, CLARION, is being extended and refined. It is shaping up to be a rather comprehensive framework for modeling and understanding skill learning in a variety of circumstances. Cognitive mechanisms, such as working memory, episodic memory, goal structures, semantic memory, implicit associative memory, as well as motivational and meta-cognitive constructs, are being developed. With the development and specifications of these mechanisms, simulations using CLARION have provided interesting interpretations in a number of task domains and more simulations will be under way.

Contributions to Basic Research

The current work advances basic research in the areas of learning and cognition. One product of this effort is a conceptual framework, which addresses the ways these two types of knowledge interact to produce expertise (e.g., in tasks that require both speed and accuracy), which is an open, but important, issue. This framework (the CLARION model) suggests that performance can be controlled by either a subconceptual (connectionist) knowledge base (implicit mode) or application of a symbolic conceptual mental model (explicit mode). Implicit control is fast but prone to error, particularly in early levels of skill acquisition. Explicit control is more accurate but slow to apply, and prone to loss by forgetting over a retention interval. We have found that reflection about how one is performing the task can be very beneficial following short periods of practice. However, it is often even more effective when learners are provided hints that direct their reflection in productive directions. These are important findings that advance our understanding of the interaction of the two types of knowledge.

A computational cognitive architecture, CLARION, markedly different from other existing cognitive architectures, is developed in this work to simulate and capture a range of quantitative data that are related to the interaction, based on the above ideas. This will help us to explain (eventually to predict) training and learning processes. We carried out simulation experiments in the domains of process control tasks, artificial grammar learning tasks, as well as some other tasks, and generated new insight and interpretations that can further explicate the interaction between implicit and explicit processes. These outcomes (data, models, and theories) provide a more detailed, clearer and more comprehensive perspective on skill learning. Our models and theories will be useful in better understanding human skill learning, as well as in helping to improve training processes. Our models and theories may also be useful in understanding individual differences in skill learning (based on the implicit/explicit interaction).

Potential Army/Military Applications

This research links to applied programs on training and learning. Specifically, our basic research involves understanding learning and cognition in terms of the interaction between implicit and explicit processes, and thus, it involves testing learning and training principles that may be used to enhance human learning. The goals of the basic research align with those of the applied programs. Both focus on training effectiveness. Hence, work from our basic research could inform and be applicable to work in the applied programs. For example, our work may offer training principles that enhance training effectiveness, which can then be incorporated into an automated tutoring system. There are of course many other ways in which the result of our basic research program could be employed in the applied programs' systems, tools, and other products.

It is expected that applications of this research for the Army will be in the area of training and human performance. A basic problem for the Army is how to ensure that novices in a Military Occupational Specialty (MOS) move quickly to more advanced performance (and perhaps to expertise) as a result of their training. In addition, most training focuses on teaching conceptual knowledge rather than setting up the opportunity for substantial experiential (implicit) knowledge. While this may be appropriate for some specialties, some other specialties involve working with complex systems that are better learned initially through extensive experience than with lectures or textbook lessons. As service personnel gain in expertise, it may often become appropriate to focus more on conceptual knowledge. Our research will lead to some initial guidelines about 1) what types of training are most appropriate for learning complex systems, 2) what types of training are most appropriate for a given level of experience, 3) how MOS experts might best communicate their knowledge to MOS novices, and 4) individual differences in training performance and how these can be explored to enhance learning (or in other words, developing individualized, adaptive training). We would be interested in talking with our liaison officers about implementing and transitioning these ideas in the future.

Final Summary

The results of our experiments support our theory/model of the interactions of implicit and explicit learning processes during skill acquisition. Strictly implicit training is effective for fast responding, but is prone to error. Strictly explicit training results in slow, but accurate responding. A balance of both worlds (fast and accurate responding) can be obtained by using structural models in training that emphasize fast but accurate responding. Under these training conditions, learners acquire the ability to rely on implicit knowledge for generating an initial sketch of a solution and using explicit knowledge to fill in gaps or check possible errors.

Our research also demonstrates that implicitly acquired knowledge can be much more flexible than existing research suspected. It was believed that implicitly acquired knowledge would not generalize beyond experienced cases. However, we found that people could acquire knowledge from artificial grammar cases that could be recombined to generate a wide range of valid strings not yet experienced. This form of learning would be especially valuable if combined with external help that could correct minor errors, such as the computer did for our participants during the artificial grammar generation task (e.g., whenever a response reached an acceptable level it was corrected by the computer).

In the process control task, learners appear to acquire correct responses more from implicit induction rather than explicit rule generation. In fact, our college level participants were particularly bad at figuring out the relatively simple equation that determined reactor temperature, even when they were given hints about the form of the equation and a calculator to test their hypotheses. Yet a simple cue that includes three good examples, such as, "If current temperature is 10,000, then use 800 pellets", was enormously effective in enhancing learning. It appears that these hints showed learners how to look at the task in terms of finding good cases. Reflective thinking in between practice sessions did enhance performance, especially when the learner's reflection was focused on recalling good specific cases of controlling reactor temperature. This good type of "recalling instances" reflection could be induced at a group level as well, to enhance learning. Therefore, the type of training recommended for this type of complex process control task consists of short periods of fast, intense practice followed by short

intervals of reflection. Also providing learners of a few examples of good responses to specific situations can be very effective.

These results should be further developed, because they may have significant implications for Army training and for other applied areas of Army. The knowledge gained from the basic research would apply when developing training programs, with a better understanding of the cognitive processes involved in skill acquisition, both implicit and explicit, and when addressing how to increase training effectiveness. In particular, this basic research program addresses an important issue when developing training programs, how implicit and explicit processes interact and impact skill learning and performance. Much more work is needed in this area. Similarly, a focus of research in decision making is on cognitive skills training methods that facilitate rapid, accurate decision-making. Although this is a different focus, the current research could inform the applied research on decision making of an important consideration in decision-making -- implicit and explicit cognitive processes and their interactions.

Some of the above hypotheses have been verified through computational simulation using CLARION. In particular, the CLARION simulation of artificial grammar learning has led us to formulate and test those hypotheses concerning artificial grammar learning. At the same time, discrepancies between theoretical models and experimental data have led to new designs of further human experiments. It appears that CLARION has the potential to be a comprehensive theory of a range of psychological tasks/domains. Future research should be conducted to further develop and validate this approach.

The Integration of Implicit and Explicit Knowledge in Skill Acquisition

Contract #: Not yet assigned
Institution: Rensselaer Polytechnic Institute

Contract dates: 9/05-10/08
PI: Ron Sun
Co-PI: Robert Mathews
Liaison: Dan Horn, RACO

Research Question(s) – How is implicit knowledge acquired from experience, integrated with explicit knowledge from analytical thinking, and what role does this integration play in skill learning and in leading to better skilled performance?

Technical Barrier(s) – The interaction of these two types of knowledge is still poorly understood and more important, the integration of these two types of knowledge is heretofore unexplored. The process of interaction and integration appears to be highly complex and multi-faceted.

Significance/Impact for Basic Research - The major contribution of this work lies in coming up with a significant new theory that explains a range of human data (learning phenomena) on the basis of the integration of implicit and explicit knowledge.

Potential transitions – Knowledge gained in this basic research may be usefully employed in:

- Future Force Warrior Training program (WP 215) - Training programs that facilitate rapid accurate decision-making.
- Various training programs: VICTOR: Virtual Individual and Collective Training for Future Warriors (WP 233); SIMAIR: Simulation-Focused Collective Aircrew Training (WP 231), and Training for Interactive Distributed Environments (WP 214) - How implicit and explicit training interact and affect skill learning.

Overview

It has been shown that high level of skill depends on both conceptual (explicit) and subconceptual (experiential, implicit) knowledge. In our prior work, we have also demonstrated that there is often a lack of awareness of implicit experiential knowledge and, in fact, implicit knowledge may be incompatible with explicit knowledge. These two problems create serious challenges for training and learning in the military as well as civilian context. The purpose of this research program is to better understand the integration of these two types of knowledge and how their integration may lead to better skill learning and performance. Specifically, we will (1) investigate the integration of implicit knowledge from experiential learning and explicitly formulated conceptual knowledge in the development of skills and expertise, (2) explore how conscious reflection and resulting conceptual knowledge may be integrated with implicit knowledge to enhance, rather than interfere with, experiential learning, (3) develop computational models and theories of human skill learning that capture the fine-grained details of the integration of these two types of learning, which may be of use in improving future training, on the basis of our experimental results.

Research Approach

This planned project investigates the integration of implicit and explicit knowledge in skill learning. In part, this work develops further a cognitive architecture CLARION, especially in terms of capturing of process details of bottom-up learning and top-down learning. These processes represent hypothesized ways of integrating implicit and explicit knowledge. Equally important are a set of human experiments to explore different methods of facilitating the integration in order to enhance skill acquisition.

The human experiments will use a more complex process control task than those typically used in the implicit learning literature. The task will involve several interrelated input and output variables. The added complexity should require learning over more extended periods of time. While the game is dynamic, it will provide feedback by discrete time steps. That is, the participant must make all desired input variable changes before entering the changes (all at once) to see how the system behaves. This division of performance into discrete time steps will provide the opportunity to reveal the learners' learning strategies and view changes in these learning processes over time.

In addition the task will contain a special model-building screen to develop and reveal explicit hypotheses about the relationships among the variables. Participants will be told that their goal is to figure out the pattern of relationships among input and output variables and correctly map these relations on the model-building screen. The model-building screen will contain icons for various variables at both current and next time steps. Participants can connect icons for time-step marked variables with labeled arrows indicating the strength (1-10) and direction (+ or -) of their relations. The screen will also allow use of two different colors on the arrows connecting variables, black for relations considered definite and red for hypothetical, but as yet unproven, relations. The task is finished when the participant builds a model of the task sufficiently complete to control performance of the system within a criterion range (e.g., 90% correct).

In various experiments, opportunities to switch from the play screen to the model building screen will be controlled. In some experiments, participants will play the game at a fast pace (must respond every six seconds) to build implicit (without explicit) knowledge of the game. Then, in a second phase of the experiment, they will be allowed access to both screens to study how they translate their implicit knowledge of the game into an explicit model of the task. In other experiments, people will be encouraged to engage explicit learning processes to learn how to play the game. They will be required to formulate and test their hypotheses by switching back and forth from the model screen to the game screen. These experiments will provide us with snapshots of how people attempt to implicitly and explicitly learn the task. Other experiments will test various ways of integrated training such as having an animated version of the model building screen on the game playing screen. The animated model will highlight correct (anticipated) and incorrect (unanticipated) changes in the system. In simpler domains we have found that such animated diagrams can enhance both speed and accuracy of performance. Other variables studied will include various hints to help build accurate models and whether task feedback is performance (error detection) focused versus discovery (creativity) focused. The later variable is expected to interact with individual differences (see Kluger and Van-Dijk, and Erez; ARI Contract # DASW01-02-K-70512).

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Accomplishments – N/A – New Start.

Contributions to Basic Research

The major contribution of this work lies in coming up with a significant new theory that explains a range of human data (learning phenomena) on the basis of the integration of implicit and explicit knowledge. One product of this effort is a conceptual framework, which addresses the ways these two types of knowledge may be integrated to produce expertise. This framework (the CLARION model) suggests that performance can be controlled by either a subconceptual (connectionist) knowledge base (implicit mode) or application of a symbolic conceptual mental model (explicit mode). Implicit control is fast but prone to error, particularly in early levels of skill acquisition. Explicit control is more accurate but slow to apply, and prone to loss by forgetting over a retention interval. Their integration may lead to better performance.

A computational cognitive architecture, CLARION, which is already different from other existing cognitive architectures, will be further developed in this work to simulate and capture a range of quantitative data that are related to the integration of the two types of knowledge, based on the above ideas. This will help us to explain (eventually to predict) training and learning processes. We will carry out simulations to generate new insight and interpretations that can further explicate the integration of implicit and explicit processes. These outcomes (data, models, and theories) provide a new perspective on skill learning. Our models and theories will be useful in better understanding human skill learning as well as in helping to improve training processes.

Potential Army/Military Applications

This research links to applied programs on training and learning. Specifically, our basic research involves understanding learning and cognition in terms of the integration of implicit and explicit processes, and thus it involves testing learning and training principles that may be used to enhance human learning. The goals of the basic research align with those of the applied programs. Both focus on training effectiveness. Hence, work from our basic research could inform and be applicable to work in the applied programs. For example, our work may offer training principles that enhance training effectiveness, which can then be incorporated into an automated tutoring system. There are of course many other ways in which the results of our basic research program could be employed in the applied programs' systems, tools, and other products.

We expect that Army applications of this research will be in the area of training and human performance. A basic problem for the Army is how to ensure that novices in a Military Occupational Specialty (MOS) move quickly to more advanced performance (and perhaps to expertise) as a result of their training. In addition, most training focuses on teaching conceptual knowledge rather than setting up the opportunity for substantial experiential (implicit) knowledge. While this may be appropriate for some specialties, some other specialties involve working with complex systems that are better learned initially through extensive experience than with lectures or textbook lessons. As service personnel gain in expertise, it may often become appropriate to focus more on conceptual knowledge. In this process, the integration of the two kinds of knowledge is expected to be highly important. Our research will lead to some initial guidelines about how to best facilitate knowledge integration and thus learning and performance improvements.

Future Plans

Our contract will begin towards the end of FiscalYear 2005. We will first acquire new equipments and develop software for conducting human experiments. Then on that basis, we will begin to conduct the first set of experiments as specified in our proposal.

Simultaneously, we will develop the basic outline of a computational model for capturing various methods for integrating implicit and explicit knowledge in skill learning, namely various bottom-up and top-down learning algorithms. We will then test them against human data to be generated from human experiments. We will also work on further cognitive architecture developments.

We will start to prepare manuscripts of theoretical and/or experimental papers, arguing and developing our unique approach.

RACO RESEARCH OBJECTIVE #2:

Provide fundamental knowledge to improve leader and team performance.

Research that falls under this heading provides concepts and methods for accelerating leader development, understanding and developing leader adaptability and flexibility, and discovering and testing the basic cognitive principles that underlie effective leader-team performance. Understanding the dynamics of small group leadership in face-to-face and distributed team environments is critical to this research objective as well.

The Leadership Formula: P x M x D

Contract #: DASW01-01-K-0004
Institution: The Center for Outstanding
        Leadership

Contract Dates: 09/01/01-03/01/2004
PI: Dr. Reuven Gal
Co-PI: Dr. Micha Popper

Problem(s)/Research Question(s) – 1) How leaders differ from non-leaders in terms of potential (P – psychological capacities), motivation (M) and developmental experiences (D) from early childhood; 2) How the variables in the P.M.D formula affect the emergence of leadership.

Technical Barrier(s) – Not much is known about how leaders develop. The literature-includes mostly biographies and psycho-biographies, and some psychological studies based on retrospective recollections of leaders. The lack of psychological studies on leadership development stems from absence of models and empirically testable conceptualizations.

Significance/Impact for Basic Research – The research addresses three leadership concepts theoretically and empirically. These concepts are leadership potential, motivation to lead, and leadership development.

Potential Transitions – Knowledge gained in this basic research may be usefully employed in:
- Selection, Classification, and Performance Metrics for the Future Force Soldier (ATO IV.HS.2002.01)
- Accelerating Leader Development (WP 269, 295, and ATO: III.HS.2004.01)
- Assessing and Developing Leaders for Special Operations Units (WP 218).

Overview

The conceptual framework underlying the study suggests that leadership is a function of a given potential (P), relevant motivation (M), and certain developmental processes (D). These three components comprise the "Leadership formula." This formula provides a theoretical framework within which internal aspects, motivational needs and developmental processes are studied as antecedents of leadership. Our argument is that those who possess certain psychological capacities (P) (e.g., high self-efficacy, or a low level of anxiety), have a strong motivation to lead, have undergone relevant developmental processes and are "equipped" with certain developmental dispositions can become leaders.

Our research hypotheses are:
1. "Leaders" will have a higher potential (certain psychological capacities) than "non-leaders."
2. "Leaders" will have a higher motivation to lead than "non-leaders."
2a. "Leaders" will have a different motivational profile from "non–leaders."
3a. "Leaders" will report more "leadership-shaping experiences" (LSE) than "non-leaders."
3b. "Leaders" will experience different "leadership –shaping experiences" than "non-leaders."
3c. "Leaders" will be characterized by higher levels of "openness" to new experiences than "non-leaders."

Research Approach

This research is based on a comparative examination of several samples of IDF soldiers (from Infantry and Armored units) undergoing their basic-training. By distinguishing "leaders" from "non-leaders" and subsequently assessing various P, M and D measurements, this field study enabled us to examine our three categories of hypotheses relating to the leadership formula: Potential, Motivation and Development. The questionnaires were administered to the soldiers in two phases: at the beginning of their basic training and after a year of service. In the second phase, we returned to our original subjects and administered the three questionnaires that measure those attributes that are conceptually dynamic and may change over time (General Self-efficacy, Motivation to Lead, and Openness to Experience).

Accomplishments

We obtained questionnaires from 402 IDF soldiers and conducted 60 LSE interviews. We have finished analyzing the questionnaires and the results so far indicate that:

- Potential to lead (P): All the potential variables differentiate significantly between "leaders" and "non-leaders." An article in *Military Psychology* based on these results is currently in press (Popper, M., Amit, K., Gal, R., Sinai, M. & Lissak, A., 2004. The capacity to lead: Major psychological differences between "leaders" and "non-leaders." *Military Psychology*, 16, 4, 245-263).
- Motivation to lead (M): "Leaders" have higher motivation to lead than "non-leaders." Four motivation to lead components significantly differentiate between "leaders" and "non-leaders." An academic journal paper, based on these results, is under review in *Military Psychology*.
- Leadership Development: "Leaders" were found to be characterized by higher levels of "openness" (the reason for this was also studied) and report more "leadership-shaping experiences" (LSE) than "non-leaders." The results were analyzed quantitatively and qualitatively to study the types of experiences that affect leader development. An academic article based on the quantitative results will be submitted soon to *Leadership Quarterly*.

- We are now analyzing the qualitative data concerning the development issues.

Contributions to Basic Science

This investigation will contribute to basic research as it provides a coherent and integrative framework for dealing with the following questions: What kind of individuals become leaders? What is their psychological uniqueness and how is it formed from early childhood? The developmental aspects in particular are known as an uncharted area waiting to be studied. Specifically, our research focused on three components: Leadership potential (P), motivation to lead (M), and leadership development (D). We examined these in our research, using existing psychological instruments to test the P component, and constructing new instruments to test the M and D components. We expanded the concept of "motivation-to-lead," a concept scarcely examined in the literature, both substantially and technically. We constructed three developmental-leadership assessment tools: Openness to Experience questionnaire, LSE interview and LSE questionnaire. Finally, we constructed a questionnaire identifying "leaders" and "non-leaders."

Potential Army/Military Applications

This research was conducted in the Israeli Defense Force (IDF). Unlike civilian organizations where leadership is diffused in the manager's functions and formal authority, in the military, pure leadership is much more prevalent and, in fact, is an essential driving force that generates the soldiers' readiness to risk their lives.

Furthermore, within the military the distinction between "leaders" and "non-leaders" is much more evident than in most other institutions. This distinction is somewhat contaminated, however, in those military organizations (such as the U.S Army) where the distinction between officers and non-officers is made "institutionally" (through military academies), rather than "naturally" (through a gradual selection process). A salient example of the latter type is the IDF. Starting on an equal footing, all Israeli conscripts undergo an ongoing selection process during their initial training period, and out of this prolonged process emerge those who eventually become officers or NCO's. This unique situation makes the IDF an extraordinary natural laboratory for examining leadership development. Moreover, this field study was conducted on two different army corps, Infantry and Armored Corps, in order to examine whether they reflect different leadership-forming processes.

Overall, our research may provide a unique opportunity to understand how "leaders" differ from "non-leaders" and what makes pure leadership. Furthermore, our research may unravel some of the mysteries connected with the nature-nurture origins of leadership, as well as suggesting some important and practical implications related to leader selection and development (i.e. training) in any modern military.

Final Summary

In all three components (P.M.D) of the leadership formula, differences were found between leaders and non-leaders. Leaders were found to have a lower level of trait anxiety, higher levels of openness, self-efficacy and optimism, and to be characterized more than non-leaders by an internal locus of control and a secure attachment style. In distinguishing between "fundamental components" (e.g., openness, and optimism, locus of control – aspects that are close to the notion of "disposition") and "learned components" (e.g., self-efficacy), we found that fundamental components affect the mode and intensity of a leader's development. The types of relationship between these components (interactive or additive) are explored and discussed.

The hypotheses were derived from a conceptual framework that was formulated on the basis of various leading psychological theories in the domains of personality (e.g., anxiety, openness), developmental psychology (e.g., attachment theory), and theories of motivation (e.g., expectancy theory). The findings indicate that the "integrative package" that was constructed has a significant theoretical contribution as it combines different psychological views and serves as a framework for creating testable concepts in a field known as a void. Besides its theoretical contribution, this research has direct applications in the domain of selecting, assessing and developing leaders, particularly at early stages of their lives.

Leadership: Enhancing Team Adaptability in Dynamic Settings

Contract #: 1435-04-03-CT-71272
Institution: University of Pennsylvania

Contract Dates: 01/01/03-09/30/06
PI: Dr. Katherine J. Klein
Co-PIs: Dr. Steve W. J. Kozlowski
    Dr. Yan Xiao
Liaisons: Stan Halpin, LDRU &
    Scott Graham, IFRU

Problem(s)/Research Question(s) – What predicts *individuals'* adaptive performance in dynamic settings? What predicts *teams'* adaptive performance in dynamic settings? What can *team leaders* do to enhance adaptive individual and team performance?

Technical Barrier(s) – While research on leadership is abundant, as is research on teams, surprisingly few researchers have focused specifically on *team leadership*. Further, it is challenging to identify, gain access to, study, and/or stimulate truly *dynamic work settings*.

Significance/Impact for Basic Research – Our findings will help to clarify the nature and antecedents of adaptive individual and team performance in dynamic settings, expanding research on (1) leadership; (2) team effectiveness; and (3) dynamic work contexts.

Potential Transitions – Knowledge gained in this basic research may be usefully employed in:
- LEADERSHIP: Developing Leaders in a Changing Army (WP 103)
- Future Force Warrior Training (WP 215)
- Assessing and Developing Leaders Within Special Operations Units (WP 218)
- Accelerating Leader Development (WP 269); Accelerating Leader Development (WP 285)
- SELECT21: Selection, Classification, and Performance Metrics for the Future Force Soldier (WP 257) and ATO: IV.HS.2002.01.
- FUTURE TRAIN: Techniques and Tools for C4ISR Training of Future Brigade Combat Team Commanders and Staffs (WP 211)

Overview

Our research is designed to illuminate the influence of individual differences, team characteristics, and leadership on individual and team performance in dynamic work environments. Dynamic settings are work environments in which:
1. Diverse specialists work in teams to perform highly interdependent tasks;
2. Tasks are high in novelty, uncertainty, and urgency;
3. The pace of work is varied and unpredictable as emergency events occur frequently but at unpredictable times;
4. Team composition (i.e., team membership) changes frequently, such that team members may not know many of the individuals on their team; and
5. Effective task performance is dependent on team member learning, development, and adaptation.

Theory and research regarding the factors that allow individuals and teams to thrive in such settings are extremely limited. Our research is designed to begin to fill this gap in the literature. Ultimately, our work will inform training specifications for leader development so that Army leaders are equipped with the skills needed to shape and influence team learning, development, and adaptability.

Research Approach

Our research approach is to use diverse, complementary research strategies to gain new understanding of the factors that influence individual and team adaptive performance in dynamic settings. We have begun to conduct new qualitative (primarily interview) data in a real-life, dynamic work setting: The Maryland Shock Trauma Center (STC). STC is the hub of Maryland's system of emergency trauma care, treating over 6,000 victims of traumatic injury each year. We are using our qualitative findings to refine our theoretical model and to develop survey measures of the antecedents of individual and team adaptive performance.

We complement the real-world insights that we gain in the STC with rigorous, experimental research in the MSU ADAPT Lab (Accelerated Development and Adaptive Performance Training). The experimental work is based on the theoretical foundation of self-regulation as a means to examine the psychological mechanisms underlying learning, motivation, and performance. The primary focus of the lab research is to identify and develop techniques that leaders can use to enhance individual learning, team development, and adaptability.

Accomplishments: Research in the Shock Trauma Center

We wrote a qualitative case study and analysis of the team leadership system that allows teams of attending physicians, residents, nurses and technicians to provide reliable and effective care to Shock Trauma patients (specifically patients in the Trauma Resuscitation Unit, or TRU). This paper received a revise-and-resubmit from *Administrative Science Quarterly* and we are working on the revision. In our newest data collection effort, we have conducted semi-structured interviews, focusing specifically on the experiences of surgical and emergency medicine residents and fellows. Our interviews were designed to provide preliminary answers to the following questions

What constitutes adaptive individual performance in the STC? Interviewees emphasized that two criteria are most indicative of adaptive individual performance: *learning* and *team citizenship behaviors*. Individuals who acquire new skills in performing medical and surgical procedures and who provide assistance to other team members' facilitate their team's adaptation to unpredictable work demands.

What individual differences predict adaptive individual performance in the STC? Interviewees' comments suggest that residents and fellows are most likely to gain new skills during their rotations within the STC if they have a strong *learning orientation* (i.e., they are eager to acquire new skills and willing and able to learn from failure and from both positive and negative feedback). Team member *goals* are also likely to be influential. Team members who expect to work in emergency medicine or trauma care – and thus regard their STC rotations as instrumental of their long-term career effectiveness – are most likely to learn a lot during their rotations. Finally, team member confidence, or *self-efficacy*, is critical as they face novel

challenges in treating patients' suffering injuries that the residents and fellows have not treated before.

Interviewees' comments suggest that *personality* and *values* may predict individuals' team citizenship behaviors best. Team members who are conscientious, agreeable, extraverted, and emotionally stable seem most likely to be attentive to opportunities to assist other team members' in carrying out their work, facilitating the work of the entire team. Further, team members who have a strong work ethic, or preference for activity, may also be particularly high in team citizenship behaviors.

In their comments, interviewees highlighted two different strategies for managing the transition to a novel work setting: *Observation* and *proactive feedback seeking*. That is, some interviewees emphasized that they learned appropriate behaviors in the new setting by hanging back and observing others. In contrast, others emphasized that they actively sought out others of all ranks and asked them for information and guidance.

These qualitative findings underscore and mirror several of the key findings emerging from Kozlowski's research in the MSU ADAPT Lab.

What constitutes adaptive team performance in the STC? Interviewees' answers to questions addressing this topic reinforced the importance of *learning* and of *team citizenship behavior*. Interviewees emphasized that effective, adaptive teams are ones in which more experienced team members teach less experienced team members to perform critical emergency medical and surgical procedures. Further, interviewees also emphasized that effective, adaptive teams are ones in which team members come to each other's assistance, helping one another to perform both the most and the least glamorous of team tasks. Interviewees' comments suggest that adaptive, high performing teams are distinguished by their *dense social networks* in which team members are linked by learning, teaching, and mutual assistance ties.

What can team leaders do to enhance individual and team adaptive performance in the STC? Interviewees identified a number of functions that leaders may perform to enhance individual and team performance. These include *communication* and *providing initiating structure* to clarify procedures, plans, and norms and to ensure that team members who vary in experience and expertise are "all on the same page." Interviewees also value leaders who *coach and teach team members*, enhancing team members' skills and reinforcing their learning orientation. Further, leaders who are *calm, well-connected to sources of information and resources external to the team*, and who *facilitate shared learning and socialization* are particularly effective, interviewees reported.

Accomplishments: Research in the ADAPT Lab

We developed a conceptual framework that specifies leader functions which leverage self- and team-regulation. Further, we conducted new experiments to develop and test our ideas regarding the antecedents of individual self-regulation and learning.

What can team leaders do to enhance individual and team adaptive performance? Our conceptual framework integrates the functional team leadership literature with work that adopts a dynamic perspective on team processes, performance, and development. It is formulated

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around two dynamic processes—(a) environmentally-driven team task cycles and (b) the evolution of team development—that create contingencies for aligning leader behavior. The framework specifies how environmental inputs create variations in task complexity, and how episodic team task cycles can be meshed with leadership functions of *preparation, action, monitor/intervention*, and *reflection*. By harnessing naturally occurring task cycles and applying the functions, leaders can leverage self-regulatory processes that underlie learning to build targeted skill sets. As team member skills improve and crystallize, it enables the leader to transition the team to more complex skills and capabilities. The result of this developmental process is a self-regulating, continuously improving, and adaptive team. The framework provides a basis for specifying team leader actions to fit shifting, episodic, and evolving situational demands, and has implications for research on leadership, leader training, and team development.

How can leaders frame the situation to enhance self-regulation? Ongoing research in the ADAPT Lab (supported in part by this project) demonstrates that an individual's orientation toward complex skill acquisition (learning or mastery vs. performance) has important effects on learning, performance, and performance adaptability; a learning or mastery orientation is superior for complex skill acquisition. A learning orientation can be induced by manipulating cues and instructions that emphasize skill mastery, learning from errors, and exploration, whereas a performance orientation can be induced by an emphasis on accomplishing performance goals, minimizing mistakes, and demonstrating proficiency. These inductions can be delivered by leader directives. This is important because such inductions are easily created and can (inadvertently) contradict training goals. For example, training is typically predicated on explicit goals to learn specific skills. If leaders also emphasize high errorless performance during training (performance frame), they induce a performance orientation that degrades self-regulation and learning. This work has implications for specifying leadership functions and training design characteristics so as enhance self-regulation, learning, and adaptability.

Contributions to Basic Science

Our research will illuminate the psychological mechanisms underlying individual and team self-regulation in dynamic work settings. Further, our research will identify leader behaviors and functions (e.g., goal clarification, feedback, coaching) that enhance individual and team self-regulation and thereby enhance individual and team learning and development in dynamic settings. Current research on leadership and on individual and team performance is dominated by relatively static, structural approaches. Our research highlights the dynamic nature of individual, team, *and* leader performance required in dynamic work settings.

Potential Army / Military Applications

Our research findings have implications for military leadership, training, selection, and team (e.g., platoon) design. The knowledge we are generating can be applied to improve leadership (in action), leader development (training specifications for leader capabilities), and training design and delivery (what we develop can be delivered by leaders in action or by technology-based training systems). Our findings can also inform the selection of soldiers for work in dynamic team settings, shedding light on individual differences that predict effective learning and performance in dynamic settings. Finally, analyses of the effects of team social networks in the Shock Trauma Center may inform team design, clarifying the influence of the nature and timing of changes in team membership on team norms and subsequent performance.

Future Plans

During the next year, we will continue research in the Shock Trauma Center and the ADAPT Lab in an effort to continue to identify individual, team, and leader characteristics that enhance individual and team adaptive performance in dynamic settings. Specific goals of our research including:

- Drawing on the findings from our qualitative field-research in the Shock Trauma Center to inform and influence research in the MSU ADAPT Lab and vice-versa.

- Conducting survey research in the Shock Trauma Center to test hypotheses regarding (a) individual–level antecedents of performance in the STC (e.g., learning versus performance orientation); (b) the influence of leader behaviors on team member learning and performance; and (c) the influence of team norms and social network structures on individual and team learning and performance.

- Conducting experimental research in the MSU ADAPT Lab to test hypotheses regarding (a) the effects of leader behaviors (mastery vs. performance inductions) on kinds and amount of feedback sought by team members in a simulated dynamic work environment; and (b) the effects of feedback on team members' goal orientation states. (In brief, mastery inductions are expected to yield more feedback seeking overall and more feedback seeking focused on self-improvement, process orientated, and deeper task strategies. In contrast, performance inductions are expected to yield less feedback seeking, with feedback choices related to normative comparisons, outcome orientated, and surface task information.)

Self-Initiated Development of Leadership Capabilities:
Toward Establishing the Validity of Key Motivational Constructs and Assessment Tools

Contract #: W74V8H-05-K-0001   **Contract Dates:** 11/1/04-10/31/07
Institution: Georgia State University   **P.I.:** Todd J. Maurer
                                               Liaison: Larry Laffitte, LDRU

Problem(s)/Research Question(s) - The problem addressed in this research is to identify and validate new individual difference characteristics that are relevant to motivating leadership development, as well as ways of measuring those differences in people.

Technical Barrier(s) - Little is known about predicting leadership development behavior because most research has been directed at predicting the performance of leaders.

Significance/Impact for Basic Research - New behavioral constructs are needed that will be useful in understanding, predicting and ultimately enhancing leadership development. It is expected that hypothesized relationships of these leadership development constructs/measures with each other and with additional predictors will help to establish their validity and potential usefulness in this domain.

Potential Transitions - Knowledge gained in this basic research may be usefully employed in:
- LEADERSHIP: Developing leaders in a changing army (WP 103)
- Accelerating Leader Development (WP 269)
- Accelerating Leader Development (WP 285)
- SELECT21: Selection, Classification and Performance Metrics for the Objective Force (WP 257); ATO: IV.HS. 2002.01.

Overview

The Army (and other organizations) must have leaders or potential leaders who continuously pursue the development of leadership skills and who are flexible and adaptable through their involvement in self-initiated development and learning experiences. The Army cannot rely solely on mandated training or learning experiences—it needs leaders or potential leaders to be motivated to pursue self-initiated development of leadership skills and characteristics. Total development must be motivated and initiated from within the person. But little is known about predicting leadership development behavior because most research has been directed at predicting the performance of leaders. Leadership development and leader performance are not the same thing. Likewise, motivation to be a leader and motivation to develop leadership skills are not the same. The Army needs a better understanding of leadership development and those behavioral constructs and assessment methods that are relevant to leadership development, especially those that involve individual sustained effort to develop leadership attributes. Basic research that addresses these issues can ultimately lead to applied research which enables better selection and development of leaders.

A key first step in this process is to develop behavioral variables/constructs and assessment methods, including a network of related variables, that would help establish the

validity and relevance of these new variables in this domain. The variables will be explored within a system of related constructs, including antecedents and consequences, to establish the relevance to other variables within the leadership development domain. There will be two general sets of variables examined in this research. The first set of variables includes variables being introduced here as new to the leadership domain. This set includes: motivation for leadership development, self-efficacy (or self-confidence) for leadership development, and beliefs about the improvability of leadership skills/attributes (e.g. beliefs that leadership can be developed vs. leadership is born). In addition, participation in leadership development activities for the purpose of learning/developing leadership skills will also be examined. The second set of variables to be examined are traditional personality and ability variables, as well as selected variables from the employee development literature, that can be examined as predictors of these new variables. In general, it is expected that hypothesized relationships of these leadership development variables with each other and with additional predictors will help to establish their validity and relevance in the leadership development domain.

Research Approach

A two-wave survey method will be used to collect data from people. The source of subjects will be an on-line research pool. Registered participants (currently $N > 46,000$) have varied demographic characteristics including racial makeup, gender, education, and a varied list of occupations. Working adults of a wide range of ages will be included, which will allow the study to focus on both younger and more mature adults.

The two sets of variables described above will be examined in the following way. First, the relationships among the leadership development constructs will be tested when data for the total set of these measures is collected in two time periods. By collecting data for these measures twice, this allows for a retest interval to examine the stability of the constructs across time and also for prospective prediction of some of the constructs onto others at a later time. For example, self-efficacy for leadership development at time 1 can be used to predict motivation to develop leadership skills at both time 1 and time 2. Likewise, motivation to develop leadership skills can be used to predict not only participation in leadership development activities at time 1 but also at time 2. So the relationships among the leadership constructs can be examined when the data are all collected at time 1. They can also be examined when the data are collected again at time 2 and the stability and prediction across time can also be tested.

The second set of variables (the traditional/existing constructs) will also be examined in relation to the leadership variables. These data will also be collected at time 1 and examined in relation to the leadership constructs at time 1, and also the leadership constructs that are measured again at time 2. This will also allow prospective prediction by some of the traditional constructs onto others at a later time. For example, personality can be used to predict self-efficacy for leadership development measured at both time 1 and at time 2.

Accomplishments - N/A-New Start.

Contributions to Basic Science

There has been a good bit of research on predicting leader performance. However, there has been relatively little research on predicting leadership development behavior.

For example, while motivation to lead and self-efficacy for leadership have been explored in research, self-efficacy for leadership *development* and motivation to *develop* leadership skills have not. Also, especially given differing ideas about whether leaders are born or made, there may be differences in how aggressively and effectively potential leaders pursue the development of leadership skills. Successful development of leadership skills depends on strong motivation to develop these skills. The current research will test a model of leadership development motivation that specifically targets motivation to develop leadership skills.

A recent research article (Ruvolo, Petersen & LeBouef, 2004, *Consulting Psychology Journal*) authored by officers in the U.S. Army is titled "Leaders Are Made, Not Born," which strongly reflects the notion that leadership can be developed. Further, there are many examples of successful leadership training and development programs. However, it is well known that people differ markedly on their beliefs that leaders are 'born or made.' Beliefs that leadership attributes are innate or fixed and are not acquirable or 'improvable' might be a fundamental belief that can set the stage for someone's overall motivation for leadership development. To the extent that a person believes that leaders are born and not made, this can be a substantial impediment to optimal motivation for developing leadership skills. This research will explore this belief and the role that the construct plays in leadership development motivation. In addition, the similarities and differences between constructs associated with leadership performance and leadership development will be addressed conceptually and empirically. This includes the distinction between self-efficacy for leadership vs. self-efficacy for leadership development, and motivation to lead vs. motivation to develop leadership skills. Differences in the antecedents and outcomes of these constructs will also be explored to establish their distinct construct validity. These issues have not been explored previously in relation to leadership development but do have great theoretical and practical promise.

Potential Army/Military Applications

Developing these new constructs in the leadership domain and establishing the construct validity of them in basic research could lead to applied research in key areas addressed by ARI. Generally, this applied research could fall into two categories: individual difference predictive studies and experimental research in which manipulations are used. First, these constructs and associated assessment methods, along with traditional predictors such as intelligence and personality, could be used as predictors of performance, motivation, development and adaptability in Army training and field settings. To the extent that these measures predict effectiveness in adapting to leadership roles and learning and developing necessary skills, these tools might be used in selection and placement within the Army to identify those individuals who will likely most benefit from leadership training and who are most likely to take initiative to continually develop and improve leadership relevant characteristics in themselves. These individual-difference constructs and assessment tools might be explored in applied research for relationships with key behavioral and performance criteria relevant to leadership and leadership development and learning in practical Army settings.

There is also a second way that developing these new constructs in the leadership domain in basic research could lead to applied research in key areas addressed by ARI. Research might be done on ways of influencing these constructs in Army personnel to improve motivation for leadership development. Variables such as self-efficacy are subject to enhancement through mastery experiences, persuasion, modeling or vicarious learning. Self-efficacy for leadership

development might also be influenced through these types of tactics. For example, some research has manipulated expectations for military personnel and found effects for increasing self-efficacy. Applied research might be conducted to determine whether self-efficacy for leadership development can be influenced, and whether this enhances motivation for development of leadership skills and subsequent development and performance. Prior research and theory suggests that this should be possible.

It should also be possible to conduct applied research on ways in which beliefs about improvability of leadership skills can be influenced. Prior research in settings not involving leadership and leadership development suggests that implicit theories of ability (beliefs about improvability of attributes) are susceptible to influence. It should be possible to determine if influences on beliefs about improvability of leadership skills have a subsequent influence on motivation to develop leadership skills and attributes as people increasingly believe that it is possible to develop and improve specific characteristics. Thus, to the extent that these constructs are developed and validated in this basic research, additional applied research could follow.

Future Plans

In the coming year (year 1 of a 3-year project), the literature will be reviewed to determine the content of the newly prepared leadership development measures. These will be compiled based on that review. Pilot or pre-work will be conducted to determine the length of time taken to complete the measures and whether there are any identifiable problems with the format and wording. A computerized/web version of the measures will also be developed this year.

Developing Effective Military Leaders:
Facilitating the Acquisition of Experience-Based, Tacit Knowledge

Contract #: DASW01-00-K-0014
Institution: Yale University

Contract Dates: 9/01/00 – 9/30/04
PI: Robert J. Sternberg
CoPI: Cynthia T. Matthew
Liaison: Joseph Psotka, LDRU

Problems/ Research Question(s) - Can reflection methods based on Sternberg's theory of practical intelligence enhance practical problem solving skills and the ability to acquire experience-based (tacit) knowledge?

Technical Barrier(s) – How we learn from experience and acquire experience-based (tacit) knowledge is not well understood. Prior work has not provided models and tools that can be used to measure and develop practical problem solving.

Significance/Impact for Basic Research - This project will extend current knowledge about the thought processes involved in how we learn from experience and develop methods to facilitate it for applications in the military, particularly leadership development.

Potential Transitions – This research can be used to promote leader development practices in institutional leader development in the Officer Education System (OES) and the Non-commissioned Officer Education System (NCOES). This objective would be sustained with technologies to move battlefield experiences into the schoolhouse, complemented by new technologies for self-development opportunities, and improved reachback to the institutions for better leverage of operational experience.

Overview

A variety of reflection methods have been used to enhance or foster the exchange of tacit knowledge in a range of workplace settings. However, there appears to be little research that has substantiated the effectiveness of these methods. Moreover, if reflection does indeed enhance one's capacity to learn effectively from experience, it is unclear what types of reflection methods may be most effective. These questions were addressed in two field experiments, which tested the effect of reflection methods based on Sternberg's theory of practical intelligence, which is distinguished from analytic and creative intelligence in this innovative theory of successful intelligence.

Consistent with the theory of practical intelligence, three types of reflection methods were developed that draw attention to: 1) factors considered in problem identification (reflection on condition); 2) chosen course of action and action outcomes (reflection on action); and 3) a combination of both reflection on condition and action. To measure the differential effect of these interventions on practical problem solving, two new military-specific case study instruments were developed to assess practical skills and tacit knowledge in military leadership.

It was predicted that reflection methods that focus reflection on both the condition and action aspects of practical problem solving would improve scores on tacit knowledge measures more than methods that focus on one or the other aspect exclusively. It was also expected that

reflection methods that focus reflection on both the condition and action aspect of practical problem solving would be superior to traditional analytical methods of reflection (e.g., assessing the advantages and disadvantages of a particular action in a given situation).

Research Approach

Two related experimental field studies were conducted to investigate the effect of theory-based reflection methods on practical problem solving in Army officer and college student samples using measures to assess experience-based (tacit) knowledge. The first study involving an Army officer sample was discontinued midway through data collection because access to officers was suspended due to the Iraq War. The second study was designed to complete the testing of hypotheses with a college student sample.

Two types of situational judgment tasks were used to assess experience-based tacit knowledge. The first type of measure contained brief problem situations (vignettes) followed by response options that participants evaluate. The second type of measure, developed for this investigation, contained extended problem situations (scenarios) followed by open-ended questions to which participants construct a response. Three reflection methods (reflection on condition, reflection on action, and combined reflection on condition and action) based on the theory of practical intelligence were designed and tested. In a single three-hour session, participants were administered tacit knowledge pre-test assessments, an experimental reflection method or control condition (practice or traditional analytic reflection method), and tacit knowledge post-test assessments. Statistical analyses were conducted to test the effect of each experimental reflection method on tacit knowledge post-test performance.

Accomplishments

Findings provide preliminary evidence that tacit knowledge can be facilitated by reflection methods that are derived from the theory of practical intelligence. The relative effectiveness of reflection method seemed to depend on the task employed.

For tacit knowledge vignettes, which provide limited information about a specific problem situation and ask participants to assess response strategies, the *combined reflection method* was effective in improving tacit knowledge scores. Scores on vignettes are measures of distance from expert responses; lower scores reflect higher levels of tacit knowledge. Figure 1 illustrates scores on pre- and posttest vignettes for each type of reflection method. As can be seen in the figure, the combined method showed the greatest reduction in distance from the experts in the post-test.

Figure 2 displays tacit knowledge scores on scenarios in pre- and post-tests for each of the reflection methods. Scenarios provide complex information about a problem situation as it unfolds over time and asks participants to construct a response to questions designed to measure tacit knowledge. For scenarios higher scores reflect higher levels of tacit knowledge. As can be seen in the figure, the *reflection on action method* was the most effective in improving *scenario* scores followed by the reflection on condition method. Perhaps because of all of the information that must be managed in the scenario task, it may have been more difficult for participants to benefit from the combined approach in a brief intervention.

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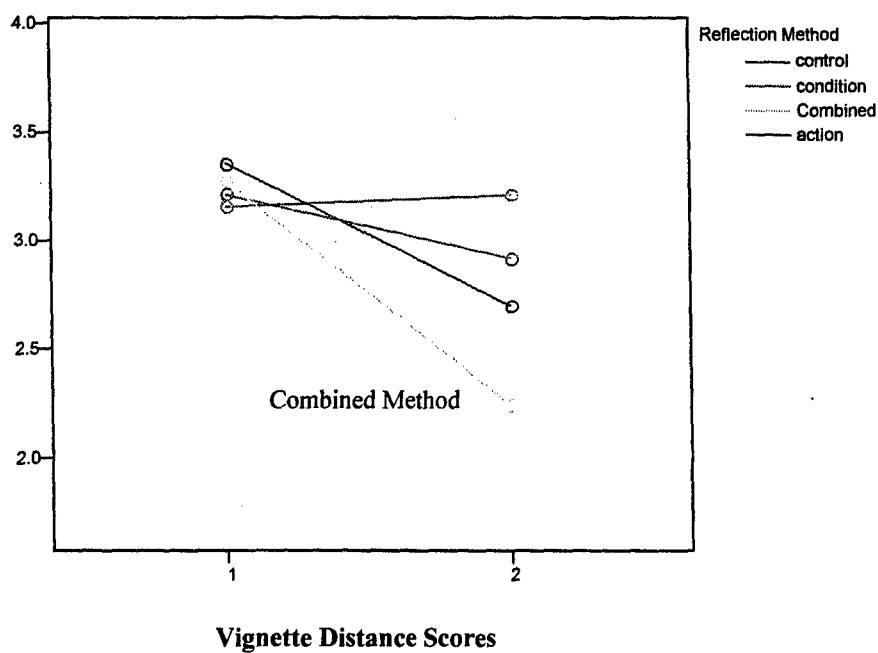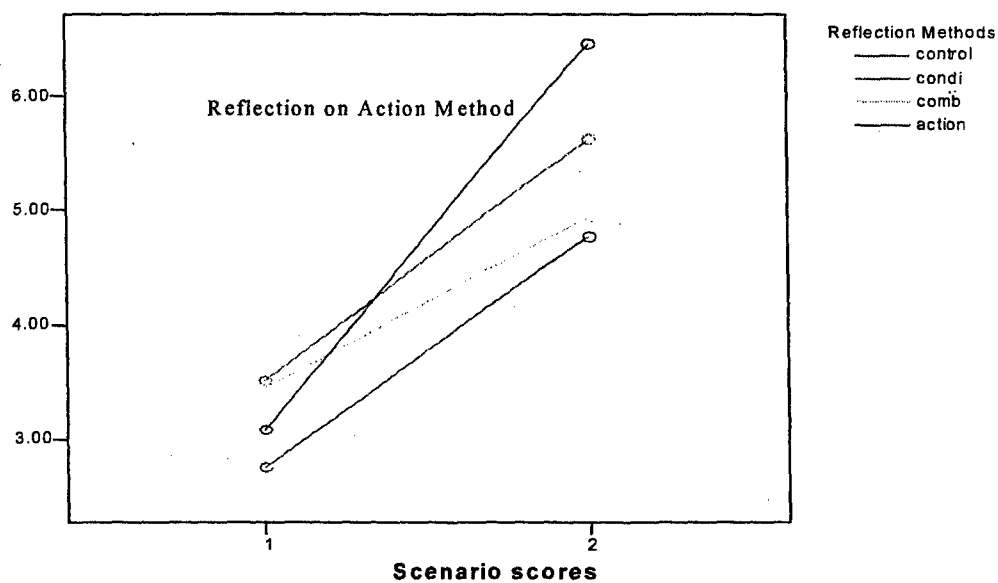Figure 1. *Performance on vignettes in pre- (1) and post-test (2)*

Vignette Distance Scores

Figure 2. *Performance on scenarios in pre- (1) and post-test (2)*

Scenario scores

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Contributions to Basic Research

This investigation illuminates a previously unexplored aspect of Sternberg's theory of intelligence by outlining the cognitive processes involved in acquiring tacit knowledge from experience, the problem solving skills involved in solving complex practical problems, and the interaction between knowledge and problem solving in expert performance. The reflection methods and case study assessments developed for this investigation can be used for further research in this area of inquiry.

Potential Army/Military Applications

Officers of all four ranks who participated in the study indicated that they learned from the reflection methods, the methods were useful for understanding how to learn from experience, relevant to the leadership problems they typically face, and as a result of participation, they plan to use future experiences as opportunities for learning.

Reflection methods developed this project can be directly applied to leadership development in the Army at multiple levels of leadership. A manual of materials was created for this purpose. The methods featured in the manual can also be adapted to specific training situations.

Final Summary

This investigation showed that even very brief reflection methods based on the theory of practical intelligence can improve practical problem solving. Reflection methods that were developed based on the theory of practical intelligence effectively promoted practical problem solving in study participants. These reflection methods appear to be more effective than no reflection or traditional, analytic approaches to reflection on experience. However, all reflection methods are not alike. The effectiveness of a particular reflection method seemed to depend upon the complexity of the task. Time may determine the extent to which a particular method is effectiveness given a particular type of task.

While a variety of reflection methods have been advocated and used to enhance or foster the exchange of tacit knowledge in a range of workplace settings, the effectiveness of these methods may vary considerably depending upon how they are designed and implemented. This investigation is a primary step in identifying theory-based methods that facilitate the development and use of tacit knowledge. There is much more work to be done to verify the effect of reflection methods on learning and performance, identify that factors that moderate the relationship between reflection method and effectiveness, and examine the transfer of training over time. Further research has the potential to uncover more about the relationship between reflection method type, time, task type, and other factors that may have bearing on practical problem solving and the acquisition of tacit knowledge. This knowledge can have direct effect on specific types of training and development in the Army and in other organizations. For example, in the Army the differential effectiveness of reflection method and modes of implementation may depend on level of leadership. More experienced officers whose experience may no longer be appropriate in the current environment, may require different methods than less experienced officers who are just beginning to build a network of tacit knowledge in military leadership.

Identifying Individual Attributes and Learning Principles that Foster Adaptive Performance and Promote Rapid Adaptability Skill Acquisition through Multiple Modes of Development

Contract #: Not yet determined.   **Contract Dates:** 1/15/05-7/31/07
Institution: George Mason University   **PI:** Stephen J. Zaccaro
                                             Liaison: Joseph Psotka, LDRU

Problem/Research Questions -
- What combinations of leader and team processes and attributes lead to maximum adaptive performance in today's military operational environments?
- What training and development principles produce the most effective acquisition and growth of leader adaptability skills?
- What individual attributes moderate the impact of training and development interventions on adaptability skills?

Technical Barriers - Past theories and models of leadership and team training are inadequate for understanding how to grow adaptive leaders and teams. Training and developing adaptability skills for both individual soldiers and teams requires training strategies that are different from those traditionally employed by the Army.

Significance /Impact for Basic Research - The successful completion of this research effort should contribute significantly to the literature on leader and team development, in particular on strategies for growing individual and team level adaptability skills through formal instruction, developmental work assignments, and self-development. We should also add new information to the small but growing literature on leader attributes patterns and their influence on leader adaptive performance.

Potential Transitions – The products of this research should provide the basis for applied research through such efforts as DoD and Army SBIRs and STTRs. Specific topics would include:
- The development of formal training programs that target leader adaptability skills.
- The refinement and validation of assessment tools that can be used in Army training and development activities to measure developmental work experiences, learning attributes, and adaptive performance processes.

Overview

       The overall purposes of this research effort are to expand current understanding about the nature of adaptive leadership and to explore the most effective ways of developing adaptability skills through three modes of Army training – formal instruction, operational assignments, and self-development. We are examining several research questions related to these purposes, including how the operations of leadership change as military environment conditions become more dynamic and adversarial. We will also explore the leader attributes that promote effectiveness under such environmental conditions. The specification of adaptive leader processes and attributes sets the stage for a consideration of best practices in leader training and development to foster growth in leader adaptability. Accordingly, we will investigate training

and development principles that are likely to produce the most effective growth of particular leader adaptability skills. We will also examine how these principles vary across different modes of Army leader development.

Research Approach

Our research approach consists of a series of studies in both laboratory and field settings. We expect to complete 2 laboratory studies with undergraduate students in which we will vary the content of training and the means by which training can be presented to future leaders. Specifically, we will focus on teaching adaptive thinking skills and, in the course of training, employ a variety of different performance scenarios to practice the use of these skills. In these studies we will also focus on student learning strategies and on specific training design approaches that recent literature suggest should foster adaptability skills.

We also expect to complete 3 studies in several classroom settings. These three studies will use primarily survey methods and leader simulation exercises. The surveys will examine the operational and developmental assignments completed by organizational managers and military officers, with the intent of identifying certain aspects of these assignments that are most likely to foster gains in adaptability skills. The exercises will be used to link growth in adaptability skills through self-development and developmental assignments to displayed adaptability in leadership simulations. We expect to complete these exercises with undergraduate students, MBA students, and military personnel.

Accomplishments

N/A – New Start

Contributions to Basic Science

This research effort should provide substantial benefits by enhancing our understanding of how to train and develop adaptability skills through formal course instruction, as well as through officer assignments and self-development efforts. This research effort should also contribute to the growing literature on how different characteristics of leaders are linked in patterns to influence leader adaptive performance, as well as the leader's responsiveness to different training interventions.

Potential Army/Military Applications

Some of the anticipated products of this research effort include training-based assessment tools and training protocols that can contribute to more effective development of soldiers and offices. Several training units, including those at Ft. Benning and Ft. Leavenworth, are particularly interested in developing more adaptive leaders. We expect the products of our research to support these and similar efforts.

Future Plans

The formal start date for this effort is January 1, 2005. We expect in the first year to:

- Design the training manipulations for the laboratory studies
- Complete data collection for the first of two laboratory studies
- Refine and extend existing surveys that measure the quality of leader developmental assignments.
- Administer the revised draft of the developmental assignment survey to managers and military personnel.
- Complete a research report on the conceptual foundations of this research effort.

RACO RESEARCH OBJECTIVE #3:

Provide fundamental knowledge for identifying, assessing, and assigning quality personnel for the evolving Army.

Research in this section is directed toward identifying and measuring the aptitudes and skills that are unique to the human performance requirements of the Future Force. Exploring the sociological and psychological factors that could influence recruitment, retention, and Army performance are important aspects of this research objective.

An Interactionalist Analysis of Soldier Retention
Across Career Stages and Time

Contract #: W74V8H-04-K-0002
Institution: Texas A&M University

Contract Dates: 6/1/04-9/30/05
PI: Gilad Chen
Co-PI: Robert Ployhart
Liaison: Michael Rumsey, SARU

Problem(s)/Research Question(s) – How do personal, situational, and temporal factors help explain retention processes at different career stages?

Technical Barrier(s) – Models of retention have yet to consider dynamic processes leading to turnover, and whether retention processes might differ at different career stages

Significance/Impact for Basic Research – Understanding how and why the decision to stay or leave an organization unfolds over time, and whether personal and situational factors differentially drive these processes at different career stages.

Potential Transitions – Knowledge gained in this basic research may be usefully employed in:
- RETAIN: Strategies to Retain Quality Soldiers (WP 271)
- Soldier Attitudes and Opinions in a Changing Army (WP 102)
- SELECT21: Selection, Classification, and Performance Metrics for the Objective Force Soldier (WP 257) and ATO: IV.HS.2002.01.

Overview

As a result of both the collapse of the former Soviet Union and the horrendous events of September 11, 2001, the U.S. has engaged in a series of conflicts around the globe, oftentimes simultaneously. In today's reality, and probably even more so in the future, the U.S. armed forces must be flexible and adaptable in their ability to deploy the same troops to qualitatively different types of conflicts, with vastly different purposes (e.g., dismantling terror and/or drug networks, homeland defense, peace keeping) and in different geographical locations. Consequently, the U.S. armed forces have put a high premium on selecting, training, and maintaining the sufficient human resources required for being competitive in this new global reality. Furthermore, effective retention has never been as consequential as it is today, given the high costs involved in attracting, selecting, and training soldiers.

Unfortunately, current theoretical models of retention provide an insufficient basis for our understanding of retention in such complex and dynamic work environments. The present research addresses three limitations of previous retention research:

1. Organizations can enhance retention through management practices directed at creating more positive work situations, and through staffing practices directed at selecting employees who would better fit the work environment. Accordingly, the first contribution of the present research is the simultaneous examination of both person variables (cognitive ability) and situational variables (social support and work challenge) as predictors of the retention process. In particular, we propose that *lower*

levels of ability and higher levels of social support and work challenge are associated with more positive levels of job attitudes, and thus lower likelihood of turnover. We further consider possible person-by-situation interactions, and propose that *the relationships between ability and job attitudes are less negative when social support and work challenge are higher.*

2. There is now a growing awareness that factors which affect work experiences may vary across career stages, given employees require and desire different things at different stages of their careers. In the context of the U.S. Army, for instance, there could be different reasons why first and second term soldiers decide to re-enlist. At early career stages, soldiers are adjusting to their new military career, and thus social support is particularly critical. However, at later career stages, soldiers are more likely to appreciate and benefit from challenging work assignments. Accordingly, a second contribution of our research is the examination of whether retention processes are affected by different factors at different career stages. In particular, we propose that *cognitive ability and social support are more likely to relate to job attitudes and retention at earlier career stages, whereas work challenge is more likely to relate to job attitudes and retention at later career stages.*

3. Finally, given that employees in many organizations (including the U.S. Army) transition from one work environment or project to another quite frequently, it is critical to know whether such transitions are associated with changes in retention decisions as well as in proximal drivers of retention outcomes (e.g., job attitudes), and whether capturing particular patterns of change (i.e., growth/increase or decline/decrease) in variables capturing the retention process can help explain additional variance in turnover. In our research, we propose that *more positive changes in job attitudes are associated with decreased likelihood of turnover.* Moreover, we argue that changes in job attitudes capture a unique phenomenon different from average levels of job attitudes, and thus changes in job attitudes should account for additional variance in retention decisions over and above average levels of job attitudes.

Research Approach

We are currently in the process of testing our propositions using field survey data collected by Walter Reed researchers (called the OPTEMPO project) from over one thousand soldiers at multiple times over the course of two years. The survey data were also linked to soldiers' ability scores, which were collected during the selection process into the U.S. Army. The surveys captured multiple aspects of the work environment, including social support (i.e., perceived quality of officer and non-commisioned officer leadership, co-worker support) and work challenge (i.e., job challenge, significance of work tasks, and whether soldiers were in deployement, in training, or in their garrison base). At each time period, soldiers also indicated their job attitudes (i.e., job satisfaction, job involvement, and general morale) and intention to re-enlist with the Army. Finally, actual turnover and career stage data are also available. These rich data are unique in that they allow us to capture and explain retention processes as they unfold over time, and at different career stages.

Accomplishments

N/A – New Start

Contributions to Basic Research

This project contributes to the employee retention literature in several important ways. First, by integrating person and situation theories of employees retention, this research provides a more comprehensive picture of the retention process and its determinants. Second, this research highlights the potential differences in drivers of retention across career stages. This is important, given it highlights key differences in employee motivation and retention at different career stages, and thus refines the boundary conditions for generalizing employee retention theories. Finally, moving beyond the mostly static retention research, this research provides a richer, more dynamic view of how and why employees' decisions to stay or leave the organization evolve over time vis-à-vis their experiences at work.

Potential Army/Military Applications

This research has the potential to advance Army/military applications in several ways. First, given that U.S. armed forces' selection systems rely heavily on cognitive ability, it is important to ensure that more qualified soldiers (i.e., those higher on ability) are those remaining in the military. By linking cognitive ability and the retention process, and by examining possible situational moderators of this relationship (i.e., social support and work challenge), the present research will identify plausible means of retaining more able soldiers. Second, identifying different reasons for turnover at different career stages could be translated into more effective practices directed at retaining soldiers at different career stages. In particular, if our hypotheses are corroborated, the implication would be to emphasize different management principles to retain soldiers at different career stages – i.e., social support would particularly important when managing first-term soldiers, and increasing work challenges would be critical later on in soldiers' careers. Finally, given this study tracks soldiers over the course of 2 years as they transition across different work assignments (i.e., training or deployment), it can inform the military regarding soldiers' experiences resulting from these transitions. More important, this study will identify various factors that could attenuate or accentuate the negative or positive experiences of soldiers' work transitions, which can be used to inform programs directed at enhancing leadership effectiveness and retention. Altogether, this research will likely help the military improve various management programs directed at enhancing retention, and help align these programs with the military's staffing strategies.

Future Plans

Our specific plans for this year are the following. First, we recently finished merging the OPTEMPO data with soldiers' ability and attrition data. Second, we're now conducting numerous psychometric tests to confirm the validity and reliability of the various study measures. Next, we will conduct various analyses to examine our theoretical propositions and hypotheses.

Measuring Average Speed of Numerical Reasoning

Contract #: 1435-04-03-CT-74083　　　　**Contract Dates:** 10/1/03-9/30/05
Institution: University of Minnesota, Twin Cities　　**PI:** Mark L. Davison, Ph.D.
　　　　　　　　　　　　　　　　　　　　　　　　Co-PI: Robert Semmes
　　　　　　　　　　　　　　　　　　　　　　　　Liaison: Michael Rumsey, SARU

Problem(s)/Research Question(s): Is time-constrained performance within a given cognitive task domain determined by one ability, called *level* of performance, or by at least two abilities, *level* of performance and *speed* of performance?

Technical Barriers: (a) Undeveloped theory of the cognitive abilities responsible for time-constrained performance of tasks having non-trivial difficulty; and (b) fallacious models and methods for measuring speed of task performance on cognitive tasks having non-trivial difficulty.

Significance/Impact for Basic Research: If our project is successful, we will provide the first psychometrically valid approach to measuring speed of performance of cognitive tasks having non-trivial difficulty.

Potential Transitions

This research could potentially lead to:

- Improved measures of critical attributes needed by soldiers for effective performance in assignments for which mental quickness is important; enhanced predictive validity of the AFQT if performance speeds in the various cognitive domains were measured
- Measures that can be used in a person-job match model (i.e., methods for classifying and assigning force members)
- Improved training programs in areas where mental quickness is important.

Overview

Few would doubt that if each person in a group were assigned a set of non-trivial mental tasks of like kind, the group's members would vary in how successfully and rapidly they performed those tasks. Psychologists have known for several decades how to validly measure a person's ability to successfully perform tasks in a delimited cognitive domain when no time-limits for completing the tasks are imposed. Surprisingly, however, they have yet to find a way to validly measure a person's overall quickness in successfully performing tasks randomly sampled from the domain.

One of the most important achievements in the field of psychological measurement during the second-half of the 20th century was the development of models to measure the ability that accounts for a person's success in performing tasks sampled from a given cognitive task domain, irrespective of the particular tasks sampled. The ability these models measure is called *level of performance*, or simply *level*. Such models, however, depend on the strong---and often overlooked or ignored---assumption that task performance is self-paced. It is natural to ask

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whether the same ability, level of performance, also accounts for success when task performance is constrained by time-limits.

One possible answer to this question is that a second ability, speed of performance, comes into play when the conditions of task performance include time-limits. Since early in the 20th century psychologists interested in individual differences have speculated that a general speed ability influences performance on timed tests of general intelligence. All efforts to measure such an ability, however, were unsuccessful, as were efforts to measure speed of performance in more narrowly-defined cognitive task domains. Many of the failed attempts to measure a speed ability were due to researchers' failure to recognize that any meaningful speed ability that might exist must be based on successful task performances rather than a combination of successful and unsuccessful performances.

Another fundamental reason why no one was able to measure any speed ability was that investigators failed to formulate a suitable model for measuring a speed ability distinct from level ability. Using mean or median correct response time as one's measure of speed ignores the likely influence of item difficulty on item response time. A person's median correct response time on a random sample of tasks from a given domain will vary depending on the particular set of tasks the person performs. The dominant measurement model for most of the 20th century, classical test theory's so-called true-and-error score model, is also unsatisfactory for measuring cognitive speed. That model postulates that success on a test item (cognitive task) is determined by just one ability, a person's true score in the given task domain. Among its serious shortcomings, the classical test theory measurement model fails to recognize the separate influences that the test-taker and the test item have on performance outcomes. In effect, the model tacitly assumes that all items on a cognitive test have the same characteristics.

To investigate whether one or two abilities account for task performance outcomes when performance is constrained by time, one must first propose a probabilistic model of task performance that recognizes the separate influences of the test-taker and the task. Modern models for measuring level of performance do recognize those separate influences, and we ourselves have proposed a probabilistic measurement model that postulates two abilities (two person parameters) and three item characteristics (three item parameters) to account for successful performance on a given item when the item has an assigned time-limit . Secondly, using item performance outcome data (i.e., item scores) obtained from a sample of subjects performing under time-constrained conditions (i.e., item time-limits), one must compare the fit of a model postulating level of performance as the sole ability determining performance on an item, with the fit of a model postulating two abilities---level and speed---as determining performance. Indeed, this is the approach we have adopted, though the speed ability we are trying to measure is an average speed obtained by varying across items the time-limits each of our subjects encounters.

Research Approach

We are conducting a field study with college students in psychology courses at the University of Minnesota as the research subjects. Students who participate in the study are paid a small honorarium and given extra credit points in their psychology course in return for completing both phases of the study. We began by defining the conditions of testing, which, together, constitute the *power performance conditions* of the cognitive task. These include

imposing no task-level or test-level time constraints; instructions urging subjects to work at their own pace so as to complete as many tasks (items) correctly as they can; assessing subjects during the time when they are most awake; making sure subjects are not sick, hungry, or taking any performance-enhancing drugs other than possible caffeine or nicotine; assuring that the testing environment is physically comfortable and free of distractions; and making sure that the set of tasks the subject is asked to perform does not include any that s/he has attempted to perform within the last 12 months.

Approximately 600 subjects will be assessed in each of two Phases. In each Phase subjects take one or the other of two equivalent forms of a numerical reasoning test consisting of items drawn from the Psychological Corporation's Differential Ability Tests, published editions of the SAT I, and published editions of the Graduate Record Exam's General Test. In Phase 1 testing, we assess each subject's level ability by randomly assigning them one of the two alternate forms and administering it under self-paced performance conditions. In Phase 2 testing, each subject takes the alternate test form, wherein each item will be administered with a response time-limit.

Two statistical models will then be fit to the Phase 2 testing data. One model assumes that a subject's level of performance, estimated using the Phase 1 data, is the only cognitive ability determining performance; the alternative model assumes that level and speed jointly determine Phase 2 performance. The Phase 2 data will be analyzed to see which model provides the better fit. If the analysis supports the hypothesis that a speed ability in part accounts for time-constrained performance of numerical reasoning items, then it would appear likely that a speed ability could also be measured in one or more of the task domains assessed by the Armed Forces Qualification Test (AFQT). Measuring such speed abilities could improve the AFQT's predictive validity for assigning people to various jobs in which mental quickness is important. The test would most likely require examinees to take similar items under self-paced and timed conditions (with carefully chosen item time limits) to obtain separate measures of performance level and performance speed.

Accomplishments:

- Replaced most of the original item pool with quantitative reasoning items taken primarily from old, published editions of the SAT-I and GRE General Test. This significantly improved the item-construct match, which in turn strengthened the validity and reproducibility of our forthcoming results.

- Overhauled the Psychology Department's LabVIEW program to improve its vocal recording capacity (in initial testing in the Fall of 2003, the program failed to properly record the audio files of nearly 50% of the first 41 subjects). The new program, tested after five revisions, performed flawlessly in a series of mock sessions. On March 1, 2004, we resumed self-paced testing of subjects.

- Administered Phase 1 testing to 307 subjects.

- Commenced scoring Phase 1 tests (includes transcribing the WAV file recordings to a spreadsheet file, classifying answers as correct, incorrect, or not attempted if a subject prematurely terminated the test session).

- Completed Stage 1 of the project (i.e., collected enough Phase 1 test data to allow rational assignment of item-level time limits for each of the items that will be administered in Phase 2's time-constrained testing).

As described in our 3rd Quarter Progress Report, it became evident that, in order to assign time limits for each item that would be used in Phase 2, we needed to collect self-paced test data from 150 students rather than from 75, as originally planned. By the end of the 3rd quarter, we still needed Phase 1 data from 15 students to reach the needed 300 subjects, and more students were recruited over the summer. Additionally, it became clear during the 3rd quarter that we would need more time to collect data from our target sample of 600 students. Given the dual constraints of competition with other research studies for subjects in the Psychology Department's subject pool, and of competition with other studies and classes for time in the Department's computer-based testing laboratory, we realized that we would need another two semesters (Fall 2004 and Spring 2005) to complete Phase 1 and Phase 2 testing of all 600 subjects. Accordingly, we asked for and received a one-year's extension of our contract with Minerals Management Service and ARI.

Contributions to Basic Research

- If we are able to show that in the domain of numerical reasoning two abilities, speed of numerical reasoning and level of numerical reasoning, govern success during time-constrained performance, then: (a) we will be the first researchers to have validly measured a person's speed of performance on a set of cognitive tasks having non-trivial difficulty; (b) we will have demonstrated that, within a given task domain, the conditions of task performance can strongly influence what cognitive abilities are measured; (c) we will have found a method to more completely and accurately summarize a person's proficiency status within the domain of numerical reasoning, and if so, we expect that our approach would likely generalize to other cognitive task domains; and (d) we will have presented strong evidence that the structure of human cognitive abilities is much more complex than is portrayed by the most widely accepted factor-analytic models (Carroll, 1993; Gustafsson, 1984); those models are based on time-limit test scores, scores which confound level ability with any speed ability that may exist for a given cognitive domain.

Potential Army/Military Applications

Quickness in problem solving under emergency or combat conditions is a highly desirable characteristic of any person serving in a command or key technical role in the Army. The desirability of this characteristic is proportional to the pace at which technology increases the volume and speed of communications. However, none of the four subtests that comprise the Armed Forces Qualification Test (AFQT) provides a measure of performance speed in any of the domains the AFQT assesses. Rather, all four parts are intended to be tests of power (Russell, Peterson, Rosse, Hatten, McHenry, & Houston, 2001, p. 77). Having recruits' speed scores in addition to their level scores could lead to important improvements in matching recruits to job

specializations, particularly in cases where those persons would need to be able to perform complex cognitive tasks not just successfully, but rapidly as well.

Future Plans

This project was extended for an additional year because of needed adjustments to the testing procedures, required revisions to the computer software used to record orally-delivered item responses, and competition for time and space in the computerized-testing laboratory that resulted in lower subject participation counts than necessary.

Accordingly, our future plans include:

- Completing recruitment of subjects until the desired sample of 600 subjects is obtained.
- Completing Phase 1 testing of the balance of our sample.
- Finishing the assignment of item-level time limits so that Phase 2 testing can proceed. For each item, it is necessary to compute the item's Phase 1 correct response time 5th percentile, 35th percentile, 65th percentile, and 95th percentile. Items from each form will then be sorted into one or another of 4 groups, such that items in a given group will possess similar correct response time percentile profiles. Each item in each group will then be assigned four possible time limits, each time-limit being equal to the group's median correct response time 5th, 35th, 65th, and 95th percentile.
- Administering Phase 2 testing to all subjects who have finished Phase 1 testing. Once the items have been assigned to the four item groups, subjects will be randomly assigned to one of four subject subgroups. In Phase 2 testing, each subject subgroup will answer four blocks of items. All of the items in each block will have the same item-level time limit (5th, 35th, 65th, or 95th percentile).
- Using the Phase 1 data to estimate each subject's level of numerical reasoning, and then using those level scores in combination with the Phase 2 data to estimate each subject's speed of numerical reasoning. Finally, we will compare the fits of our competing measurement models (level-only and speed-level) to each main subject group's Phase 2 data to determine whether the level-only hypothesis or the speed-level hypothesis is better supported.

Modeling the Strategic Role
of Basic Emotions with Cellular Automata

Contract #: W74V8H-05-P-0005   **Contract Dates:** 1/1/05-12/31/05
Institution: State University of New York, Oswego   **PI:** Craig DeLancey
                                                             Liaison: Bob Witmer, SSRU

Problem(s)/Research Question(s) – Under what conditions are emotional behaviors (particularly retribution in anger and flight in fear), which in the short term may appear irrational, rational or beneficial for an individual or their group?

Technical Barrier(s) – Ethical and technical difficulties, along with prohibitive costs, create significant impediments to human subject research that induces and observes anger, fear, and other emotions in controlled situations.

Significance/Impact for Basic Research – The research will provide a model that will help us understand how complex emotional behaviors can be beneficial or detrimental in both individual and social contexts. This can provide predictions for practical, more focused human subject research.

Potential Transitions – Knowledge to be gained in this basic research may be usefully employed in studies including but not limited to:
- ATO III.HS.2004.01 – Accelerating Leader Development (WP 269 & 285)
- LEADERSHIP: Developing Leaders in a Changing Army (WP 103).
- Assessing and Developing Leaders for Special Operations Units (WP 218).

Overview

The goal of this research is to develop a model of the minimal conditions for certain kinds of emotional behaviors – particularly flight in fear and retribution in anger – to occur and to be beneficial for an individual or for a group. The model will also produce predictions that can in turn be tested in future empirical research, including empirical research with humans.

Emotions often motivate behaviors that are essential for our survival, but sometimes they can lead to behaviors that appear irrational. Some of these seemingly irrational behaviors may in fact be irrational, but others may be behaviors that on balance benefit us if we understand them in the right context. We have as of yet little ability to distinguish these cases, or when they are likely to happen. Important tools for predicting and evaluating the decision making of individuals have been developed in economics and related fields of inquiry. In general, these tools are based on the assumption that individuals are rational agents who evaluate the expected outcome of the choices before them, and then make choices that lead to their most immediate benefit. However, actual empirical research into human decision making reveals some surprising behaviors inconsistent with a simple interpretation of these kinds of theories. An early and surprising result of experimental economics was the discovery of an unpredicted and seemingly irrational behavior in ultimatum games that appears to be caused by anger or another retributive affect (Roth 1995). An ultimatum game is a situation in which one individual is given some utility (typically money) and that agent

must decide how to share this utility with another agent. The receiving agent has no say in the distribution, but can decide to "veto" the offer, resulting in neither individual getting anything. Traditional economics, based upon a simple decision-theoretic analysis, predicts that the receiver will never exercise veto, but will rather accept any offer, since something is better than nothing; and predicts that the distributing agent, knowing this, will always distribute as little as allowed in the game, and retain the rest. However, in actual experimental tests with human subjects, the veto is frequently used in response to minimal distributions. Thus, it appears that people often prefer less utility for themselves in order to punish others whom they perceive as making unfair distributions. One interpretation of this behavior is that individuals undertake retributive behaviors because they are angry. It is a likely hypothesis that such behavior may be rational in the long-term if it tends to enforce more equitable distribution for either that individual, or for their social group. Similar kinds of seemingly irrational, but rational behaviors may arise from fear, where, for example, a fast processing of threats can benefit agents confronted with a great deal of information and who need to quickly avoid threats, but this ability can lead to actions detrimental in the short term.

Both retributive and flight behaviors also appear to have an important social element. Agents may be more likely to be afraid in a peer group where others are afraid (Hatfield, Cacioppo, Rapson 1993), and retributive behavior appears to be more common when individuals in groups perceive that the group (not the individual) is responsible (Milgram 1974). Both kinds of cases are consistent with a hypothesis that some emotions, such as fear and anger, can be both excited and inhibited by the observable emotions of others in one's social group. Recent analysis has also raised the possibility that individuals determine whether to express an emotion or suppress it based on evaluation of the expected social outcome (Griffiths 2003). Such factors ensure that group behavior can be significantly different from individual behavior.

The general notion that emotions have a special role to play in strategic action has received growing confirmation in a range of other sciences. Neuropsychological studies of ultimatum game performance have confirmed the role of brain substrates of emotion in ultimatum games and other kinds of games (Sanfey et al 2003, Montague and Berns 2002). Emotional deficits arising from brain damage have been identified that result in poor gambling and strategic choice behavior (Anderson et al 1999; Bechara et al 1994). The neural substrates of fear have become well understood (Panksepp 1998, LeDoux 1984), and the effect of fear on attention and other capabilities required for decision making are increasingly being investigated (Bishop et al 2004).

However, progress in psychology and neural sciences fails to address two important features of the role of emotions in strategic action. First, existing models typically have no way to account for a benefit of emotional behaviors that stretches across games, or that influences the social context that in turn determines the structure of future games. For example, one utility of retributive behavior may be to enforce social conventions (such as fairness in various distributions) that benefit on average the individual in question. Exploring such a possibility requires some modeling of social interactions over both a range of games, but also in a context where behavior shapes future interactions. Second, there is insufficient attention to the complex social interactions that such emotions may require. We may need to explain the role and utility of a basic emotion in an agent's action not only in terms of how it may have utility to the agent either immediately or by helping to maintain certain social conventions from which the agent benefits, but also in terms of how the display of the emotion affects other agents.

Experimental conditions and existing models are not yet able to address such possibilities. Furthermore, we cannot expect psychology or neural sciences to explore these problems in the near term with animal-subject experiments or human-subject experiments, because the requirements of appropriate experiments are prohibitive. It is very difficult to induce fear, anger, and other emotions reliably and with controlled and significant intensities in subjects. It is even more difficult to induce such emotions in only selected subjects in groups. Finally, it is cost-prohibitive to generate sufficient test cases to control for the large error one can expect in subject interactions because of their inherit complexity. For these and other reasons, the strategic role of basic emotions will remain intractable to human and animal experiments for some time to come.

Research Approach

The project will use a technique called genetic algorithms to develop and test possible strategies that simple agents may use in a range of games or simple strategic situations. This technique allows for the evolution of solutions to very complex problems. The problems to be answered in this case are concerned with when it is beneficial to adopt flight or retributive behavior. A series of hypotheses about the conditions for the evolution of such behavior will be tested under conditions of varied games (strategic situations) and varied capabilities for the agents.

Accomplishments
NA – New Start.

Contributions to Basic Science

The project will provide a new approach to modeling the strategic role of emotions that augments and extends standard game-theoretic or decision-theoretic approaches. The interpretation of the final model and results can result in a new set of ways to conceive of the role of several important emotional behaviors.

Potential Army/Military Applications

Utilizing and controlling fear and anger are essential parts of the soldier's performance, especially in combat situations. Understanding fear and anger can also have a significant role to play in understanding and predicting the actions of opponents. The working hypothesis of the research is that some emotional behaviors can be better understood with a model that describes the individual and social conditions in which they can be beneficial. This can also explain conditions under which some emotional behaviors can be detrimental, and provide predictions of what generates such emotional behaviors.

The model will provide empirical and conceptual benefits. First, predictions from the model could be tested with empirical human subject research. Ideally, empirical confirmation of the simulation model would then allow for the determination of conditions that would encourage beneficial emotional behaviors and discourage detrimental ones; or, if desired, vice versa. For example, confirmation of the existence of a reliable strategic role for contagion of emotions (the positive influence of one individual's emotions on the predisposition of others in the peer group to have that same emotion) could provide an improved understanding of when it would be useful to

encourage the display of emotions. Second, the model could also provide a set of conceptual tools to enable individuals to understand emotional behaviors. For example, provided with new ways to understand how fear and anger benefit and harm us, and how they act in social situations, officers would be empowered to better motivate or predict the actions of those under their command.

A Valid, Culture-Fair Test of Intelligence

Contract #: New Start. Not yet assigned.   **Contract DATES:** To be determined.
Institution: Case Western Reserve University   **PI:** Joseph F. Fagan
                                              Liaison: Peter Legree, RACO

Problem(s)/Research Question(s) - Can a racially unbiased test of the ability to process information predict how well young adults will succeed in college classes?

Technical Barrier(s) - Current theories of intelligence are based on an assumption that all those taking IQ tests have had equal opportunity for exposure to the information being tested. Thus, past efforts to develop an intelligence test that is culture-fair have not been successful.

Significance/Impact for Basic Research – This research will test the theory that intelligence is information processing ability (Fagan, 1992, 2000). Specifically, how much you know (your IQ) depends not only on how well you process information (your intelligence) but also on the information given to you by your culture to process. Current research on a theory of intelligence as information processing finds racial differences in IQ to be due to cultural factors. A test of information processing promises to be the first valid, culture-fair test of intelligence.

Potential Transitions -The results of this research will aid in gaining the objectives of:
- Future Force Warrior Training (WP 215)
- Training Small Unit Leaders and Teams (ATO: IV.HS. 2003.06)
- SELECT21: Selection, Classification, and Performance Metrics for the Future Force Soldier (WP 257) and ATO: IV.HS. 2002.01.
- LEADERSHIP: Developing Leaders in a Changing Army (WP 103)
- FUTURE-TRAIN: Techniques and Tools for C3ISR Training of Future Brigade Combat Team Commanders and Staffs (WP 211)
- Assessing and Developing Leaders for Special Operations Units (WP 218)
- Accelerating Leader Development (WP 269); Accelerating Leader Development (WP 285).

Overview

The purpose of this research is to test the predictive validity of a racially unbiased test of intelligence. The test is based on the ability to process new information. Preliminary work indicates that this new, culture-fair test of intelligence is as predictive of academic achievement as are standard academic aptitude tests. Differences in the intelligence quotient (IQ) between Blacks and Whites on the order of about 15 points are well documented. Jensen (1998) considers such racial differences in IQ to be due to differences in basic intellectual ability. In making this argument, Jensen assumes that the opportunity for exposure to the information being tested on conventional IQ tests has been the same for Blacks and Whites. In contrast to Jensen, Fagan assumes (Fagan, 1992; Fagan, 2000; Fagan & Haiken-Vasen, 1997) that the IQ score is a measure of knowledge. How much a person knows (their IQ) depends on the person's information processing ability and on the information the person has been given to process. In this view, if group differences in IQ are not accompanied by group differences in information processing, then the search for the causes of the IQ differences should be directed toward differences in access to information.

Fagan & Holland (2002) investigated the contributions that intellectual ability and access to information make to racial differences in IQ. Blacks and Whites (community college students) were compared on their knowledge of the meanings of words, a task that typically results in racial group differences in IQ. The Black and White participants in the Fagan & Holland (2002) studies were highly representative of the U.S. population with regard to age and educational level (U. S. Census Bureau, 1999). Fagan & Holland (2002) insured that Blacks and Whites were given equal opportunity to learn the meanings of novel words and conducted tests to determine how much knowledge had been acquired. For example, participants might be exposed to a sentence such as "Tubby had a big fat venter" and asked to indicate whether a "venter" was a body part or a mental state. On a later test of vocabulary knowledge, the word "venter" would be presented with: "a. height, b. candle, c. badge, d. belly, and e. opening" as choices. Fagan & Holland (2002) controlled for the possibility that the particular people chosen to represent each racial-ethnic group might, by chance, simply have been equal in vocabulary knowledge to begin with. Thus, the tests of a person's knowledge of the newly learned words were intermixed with similar multiple choice tests for knowledge of the meanings of different words, words for which no special training in the experimental situation had been provided. The choices for a word more frequent in English such as "situate" (to place), for example, were: "wear, add, take, study, and place". Whites were, as expected, superior to the Blacks in untrained vocabulary knowledge. However, when equal opportunity for exposure to the meanings of words was experimentally assured, Whites and Blacks were equal in vocabulary knowledge. Fagan & Holland (2002) concluded that Blacks and Whites do not differ in the ability to process new information and that the search for racial differences in knowledge (IQ) should be aimed at differences in the information to which people from different racial groups have been exposed.

In a second series of studies (Fagan & Holland 2003), Blacks and Whites were again compared for their knowledge of items commonly employed in tests of IQ, i.e., the meanings of sayings, of similarities, and of analogies. The participants were later tested as to the extent of their newly learned knowledge. For example, participants learned that the saying "fry asparagus" means "get lost, take a hike". Later they were asked if "fry asparagus meant to plant seed, to make supper, to come again, or to go away". They also learned that "An ancient animal has been found who saw with one eston and listened with one ewot." Later they were asked how "eston and ewot" were most similar: "a. body parts, b. start with E, c. relatives, d. senses". A second group of students were presented with sayings, similarities and analogies based on specific previously acquired knowledge. A saying based on such specific information might be: BENEDICT ARNOLD a. President b. Patriot c. Monk d. Traitor. If Blacks and Whites are equally able to process information, they should be equally able to answer questions based on newly learned information. If equal access to specific information is not culturally available, Blacks and Whites should differ in answering questions based on specific information. Comprehension based on newly learned information (whether for sayings, similarities, or analogies) did not vary by race. At the same time, knowledge based on specific information (no matter the material tested) was higher for the Whites than for the Blacks. Thus, when information was equally available, Whites and Blacks were equal in knowledge.

The data of Fagan & Holland (2002, 2003) support the view that cultural differences in the provision of information may account for racial differences in IQ. Specifically, the results indicate that IQ differences between Blacks and Whites have to do with experience. The proposed research focuses on the implications that the results of the Fagan and Holland studies have for the development of a valid, culture-fair test of intelligence. In fact, a preliminary study

indicates that this new, culture-fair test of intelligence is as valid in predicting scholastic performance as is a standard academic aptitude test.

Research Approach

Brief tests of knowledge based on word meanings, similarities, sayings, and analogies which have been proven to be culture-fair will be administered to college students 18 years or older. Students, in groups, will be given multiple choice tests of their ability to acquire new information concerning the meanings of previously unknown words, sayings, similarities, and analogies. They will also be tested for their knowledge of vocabulary in general, opposites, and analogies. An entire session (training and testing) will last about 30 minutes. With the student's written consent, Scholastic Assessment Test scores or ACT scores, GPA's and numerical grades in the Psychology course will also be obtained. Class instructors (with the student's written consent) will be asked to provide the student's numerical scores on the tests in the course but not the final letter grade. Associations between performance on the culture-fair tests, academic aptitude (Scholastic Assessment Test scores), and specific achievement (cumulative GPA's and objective test scores in college courses) will be analyzed. The proposal presented here is currently approved, through expedited review, by the CWRU Institutional Review Board for Protocol #20031104 titled "New Knowledge 2" (J. F. Fagan, PI) which can be renewed on a yearly basis for a period of four years. (See attached current approval).

Accomplishments - N/A-New Start

Contributions to Basic Science

Jensen (1998) believes that the IQ score reflects what he calls the general factor (or g) underlying intelligence. Differences in IQ scores are due to differences in g. According to Jensen, genetic factors play a primary role in determining g. Thus, Jensen (2000) believes that it may not be possible to come up with tasks that show no differences in test performance between Blacks and Whites and yet still predict academic performance. Fagan (2000) does not agree with Jensen, pointing out that the failure to develop tests of intelligence that can be fairly applied across racial groups stems from a theoretical bias to equate the IQ score with intelligence rather than with knowledge. If intelligence is defined as information processing and the IQ score as knowledge, the possibility of culture-fair tests of intelligence based on estimates of information processing arises. Fagan is not alone in such a conjecture. Williams (2000, p.17) notes that "Fagan's ideas" (Fagan 2000) of measuring thinking or information processing rather than accumulated knowledge are relevant to the debate on intelligence testing and affirmative action because . . . a true measure of processing efficiency (if it could be devised) would be fair to members of all racial and ethnic groups". The chief practical implication of the Fagan & Holland studies noted above is that it may be possible to develop culture-fair tests of intelligence that will allow basic intellectual abilities to be recognized. Specifically, the inequality of educational achievement among races in our country has highlighted a need for culture-fair tests of intelligence. For example, Blacks do not do as well as Whites on IQ tests and other tests of knowledge such as the SAT. Basing admission to higher education on such test scores means that only a small percentage of Blacks are eligible for admission to colleges and universities. A culture-fair test of intelligence would allow basic abilities to be measured and would allow those with appropriate intellectual skills to pursue further schooling.

Potential Army/Military Applications

Practically, culture-fair tests of information processing that are valid predictors of achievement have important military application. Such tests can aid in providing a valid, culturally unbiased means to select candidates for advanced education, employment, or "training in complex situations, including factors[aptitudes] that enhance transfer of training of the sort of complex tasks performed by Army personnel" (ARI BAA, p.2). Specifically, the Army can use such a measure as an adjunct to their standard measures, initially, to evaluate volunteers. Such tests can also be employed in further selection and training stages. In the field, ready information processing skills are also necessary to make quick and correct decisions based on rapidly incoming information. Basic information processing ability is also a key aptitude in the selection of future army leaders. Finally, the use of tests known to be culture-fair may provide an incentive to recruitment and re-enlistment.

Future Plans - N/A - New Start

Testing a Theory of the Determinants of Individual Job Performance for United States Army Junior Commissioned Officers

Contract #: W74V8H-05-K-0005
Institution: Personnel Decisions Research Institutes, Inc.

Contract Dates: 1/10/05–8/31/06
PI: Jeff W. Johnson
Liaison: Robert Kilcullen, SARU

Problem(s)/Research Question(s) – How do individual difference variables work to influence performance on specific performance dimensions relevant to junior commissioned officers in the U. S. Army?

Technical Barrier(s) – There is no well-established theory of the process by which individual-difference variables predict citizenship performance or adaptive performance, in either a military or a civilian context.

Significance/Impact for Basic Research – Support for this theory of performance would contribute to a better understanding of the relationships between predictors, mediators, and job performance criteria.

Potential Transitions – ARI has created various temperament scales thought to be related to adaptive performance and empirically linked these measures to the mission performance of Special Forces (SF) Soldiers. ARI is now leveraging this measure to create a self-development feedback packet for SF Officers. The measures created in this basic research project are designed to predict performance at a more proximal level than the current temperament scales, so they could be used to revise or improve this self-development package or other Soldier self-development packages that are used outside of SF.

Overview

Organizational citizenship performance and adaptive performance are increasingly important components of the Army junior commissioned officer job performance construct domain. Despite the importance of these constructs, there has been very little research studying them in a military setting. There is also no well-established theory of the process by which individual-difference variables predict citizenship performance or adaptive performance, in either a military or a civilian context. In this research, we will test a theory of the process through which individual difference variables work to influence performance on specific citizenship and adaptive performance dimensions relevant to junior commissioned officers in the U. S. Army. Johnson (2003) proposed a theory of performance determinants that goes beyond earlier theories proposed by Campbell, McCloy, Oppler, and Sager (1993) and Motowidlo, Borman, and Schmit (1997), primarily by specifying an expanded conceptualization of motivation. Johnson broke the motivation component into specific motives (e.g., organizational commitment, job satisfaction), proactive cognitive processes (e.g., self-efficacy, goal commitment), and on-line cognitive processes (e.g., self-regulation). These variables, along with knowledge, skill, and habits, mediate the relationship between indirect performance determinants (e.g., cognitive ability, personality) and any kind of individual job performance construct.

Support for this theory would provide researchers and practitioners with a tool that can be used to identify the constructs through which individual difference variables work to influence

performance on specific dimensions. This is especially important for identifying predictors of citizenship and adaptive performance. Such a tool would contribute to a better understanding of the relationships between predictors, mediators, and job performance criteria, and could be used to choose appropriate predictors for whatever criterion construct is of interest for a particular Army job. A rigorously developed and tested theory of the influence of individual differences on job performance would not only facilitate selection, classification, and training of junior commissioned Army officers, but would also add significantly to the evolving understanding of job performance.

Research Approach

In order to test this theory, we will assemble and develop a battery of instruments that are construct-valid measures of each component of the theory. All measures created for this project will be based on input from ROTC cadets. To measure task, citizenship, and adaptive performance, we will create a multisource performance rating instrument measuring performance on five different dimensions. We will also create a past behavior record to measure skill and a situational judgment test to measure knowledge, both of which will be relevant to five performance dimensions. We will create (a) a unique self-report measure of work habits; (b) a motives scale assessing attitudes, values, and preferences that predict performance; and (c) a motivation scale measuring self-efficacy, expectancy, goal content, and goal commitment. We will also use existing instruments to measure cognitive ability, personality, experience, and action control.

– The predictor battery will be administered to 200 ROTC cadets near the beginning of the semester. Criterion administration will occur near the end of the semester so we can assess the extent to which cadets performed the behaviors they intended to perform. Each cadet will be rated by approximately four peers and/or ROTC cadre/staff. These data will be analyzed using structural equation modeling to test the Johnson (2003) theory.

Accomplishments

NA – New Start.

Contributions to Basic Science

This project will advance our understanding of job performance prediction by providing evidence in support of a theory of the process by which individual-difference variables predict specific dimensions of performance. Many theories of the relationship between individual differences and job performance have been proposed, but there is very little empirical support for any of them. This is especially true for less-studied aspects of performance such as citizenship performance and adaptive performance, which are the primary focus of this research. An established model of the process by which individual differences in predictor variables lead to individual differences in specific dimensions of performance can be used to guide research linking specific predictors to specific performance dimensions by helping to identify theoretically relevant predictors for different criteria. In the proposed model, the construct of motivation is expanded to highlight how different predictors influence different components. Self-regulation is the primary component that previous models were missing. This construct is very important because it (a) is strongly related to personality; (b) helps explain how people with

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similar knowledge, ability, goals, and desire to perform differ in their level of performance; and (c) helps explain how people overcome conflicting habits to perform in accordance with their goals.

This project will also yield several potentially useful products. We will create a multisource performance rating instrument to measure task, citizenship, and adaptive performance. These performance components are important aspects of the Army junior commissioned officer performance construct domain. We will create a situational judgment test (SJT) to assess knowledge relevant to the performance dimensions chosen for study. The SJT will present the individual with a situation and a set of response options varying in their effectiveness. We will develop a past behavior record to measure skill relevant to the targeted performance dimensions. Using a highly structured format to minimize the possible confounding effect of writing ability, cadets will describe a recent situation they experienced that elicited behavior relevant to the performance dimension of interest and the behavior they exhibited. Trained raters will use standardized rating scales to evaluate the level of skill that behavior represents. By allowing respondents to describe their best example of behavior relevant to a performance dimension, we can assess the extent to which the person is able to exhibit the behavior irrespective of the extent to which they typically exhibit the behavior. To measure the components of motivation described in Johnson's (2003) model, we will create (a) a unique self-report measure of work habits; (b) a motives scale assessing attitudes, values, and preferences that predict performance; (c) a cognitive processes motivation scale measuring self-efficacy, expectancy, goal content, and goal commitment; and (d) a self-report measure of self-regulation with respect to targeted behaviors.

Potential Army/Military Applications

Support for the performance model will provide the Army with a tool that can be used to identify the constructs through which individual difference variables work to influence performance on specific dimensions. This is especially important for citizenship and adaptive performance, which are important components of Army officer jobs but have received little research attention in a military or civilian context. Such a tool would contribute to a better understanding of the relationships between predictors, mediators, and job performance criteria. For the Army, this tool would probably have its best application in identifying training and/or development needs. Given a criterion construct on which an individual's performance is in need of improvement, this model can help to identify the determinants of performance on that construct. For example, an individual possessing adequate skill and knowledge may determine that he or she must learn new self-regulatory strategies to overcome counterproductive task-related habits.

This project will yield several products that may be very useful to the Army. First, the various motivation-related instruments we will develop/assemble and validate against criteria of importance to the Army should prove to be quite useful as self-development tools. Completing these instruments can help soldiers and/or officers learn about their own attitudes, values, goal commitment, self-efficacy, self-regulatory skills, and habits relevant to five critical performance dimensions.

Second, the Past Behavior Record Form may prove to be useful for training. In particular, the evaluation guide that would be used to score this instrument will provide useful information

regarding where various skill-relevant behaviors fall on various performance continua. Moreover, the principles to be induced during the process of calibrating the performance-relevant skills to different points on these anchored rating scales will make useful learning points in training programs. The situational judgment test will also be a useful self-paced training tool. Individuals are presented with realistic situations and choose from a variety of alternative response options. Explanations of the strengths and weaknesses of each response can be developed to help the trainee understand the level of effectiveness of the chosen option and the most effective option.

Finally, the performance rating form may have applied value for performance appraisal, training needs analysis, or criteria for future validation studies. In addition, it would make a useful feedback and development tool. The performance rating form will be a multi-source rating instrument. As such, it will not only provide a profile of strengths and weaknesses, it will provide information about discrepancies between how an individual is seen from different perspectives (i.e., subordinates, peers, superiors). It would be extremely useful, for example, for a junior officer to become aware of differences between his or her self-perceived performance and the perceptions of his or her performance held by subordinates.

Future Plans

During fiscal year 2005, we will conduct the following activities:

- Conduct kick-off meeting: We will hold a kickoff meeting with ARI personnel to discuss the work plan and to refine or redirect our work activities.

- Obtain participants for instrument development workshops: We will contact ROTC unit commanding officers to arrange for participants. We will then recruit cadets and schedule them for the workshops in which they express interest.

- Define performance domain and create criterion measure: We will identify five dimensions of performance representing task, citizenship, and adaptive performance that are relevant to ROTC cadets. Then we will develop a performance rating form to measure performance on these dimensions.

- Identify and obtain predictor measures: We will assemble a battery of predictor measures that includes measures of general cognitive ability, personality, and experience.

- Conduct situation generation workshops for developing knowledge measure: We will conduct two situation generation workshops in which cadets will be presented with definitions of the target dimensions. They will then be asked to generate situational item stems by writing brief descriptions of situations they have witnessed or experienced, in which a cadet demonstrated a high or low level of performance on one of the target dimensions.

- Develop skill measure: We will create a past behavior record form that asks the respondent to describe (a) a situation from the respondent's recent past that required

the respondent to exhibit behavior relevant to the target dimension, (b) the action taken by the respondent in response to the situation, and (c) the outcome or result of the behavior. We will then conduct two workshops to collect examples of past behavior. We will ask participants to describe one or two ROTC-relevant behavioral examples from their own past for each dimension using the Past Behavior Record form. We will then develop an evaluation guide by (a) conducting a workshop in which knowledgeable cadets or cadre officers rate the effectiveness of each behavioral example, (b) inducing the principles underlying the rating process, (c) developing rating scales for each performance dimension that contain behavioral statements describing high, medium, and low levels of effectiveness for each facet of the dimension, and (d) combining these scales with rating instructions. The evaluation guide will then be pilot tested.

- Assemble action control and habits measures: We will create an action control scale for this study by writing instructions and assembling the items from Diefendorff et al. (2000) into a questionnaire format. We will develop a scale to assess habitual tendencies with respect to relevant performance dimensions by adapting the Self-Report Habit Index (Verplanken & Orbell, 2003) to our target behaviors.

- Prepare for data collection: We will identify participating ROTC programs for data collection and obtain IRB approval at each university.

Goal-Driven Perception and Cognition in Complex Social Environments

Contract #: W74V8H-05-K-0003   **Contract Dates:** 1/1/05-12/31/07
Institution: Arizona State University   **PI:** Douglas T. Kenrick
                Co-PI: Steven L. Neuberg
                Liaison: TBD

Problem(s)/Research Question(s) - How do common social goals relevant to military situations (e.g., self-protection, other-protection, retribution) influence early-stage cognitive processing of complex social environments (e.g., which person in a crowd we choose to pay attention, how we interpret this person's facial expression). How do these goal-driven processes shape important down-stream behavioral decisions (e.g., to shoot vs. not shoot a possible enemy combatant)?

Technical Barrier(s) - Until recently, little effort has been made to link theory about fundamental social goals and their associated emotions to theory about early-stage information processing, or to use modern methods of cognitive science to rigorously explore the possible influences of such goals on cognitive processing.

Significance/Impact for Basic Research - This research will help conceptually integrate two important, but disconnected, research literatures while also providing empirical data that tests hypotheses about goal influences on cognitive processing of complex social environments.

Potential Transitions - Knowledge gained in this basic research may be usefully employed for identifying those individuals most susceptible or resistant to particular goal-related information processing biases, identifying those individuals most in need of training to overcome such biases, and designing training programs to mitigate such biases. We suggest that our research may be most directly relevant to the following applied programs:

- Selection, Classification, and Performance Metrics for the Future Force Soldier (ATO: IV.HS. 2002.01).
- Future Force Warrior Training (WP 215)
- Ground Systems Team Training (WP 302)
- VICTOR: Virtual Individual and Collective Training for Future Warriors (WP 233)
- Assessing and Developing Leaders for Special Operations Units (WP 218)

Overview

Soldiers often encounter extremely complex situations rich in social information about which they must rapidly make difficult, life-or-death decisions. Cognitive limitations dictate, however, that one cannot attend equally to each individual in such settings or to all characteristics of any given individual. Rather, attentional and information processing must be directed selectively to a small subset of individuals and characteristics. The selective direction of cognitive processing often occurs automatically, without conscious intent, and is highly suscepible to biases that can potentially lead to serious errors (e.g., failing to process clues of an impending fatal ambush or mistaking an innocent civilian for an armed insurgent). The aim of the proposed research is to assess how common social goals—self-protection, other-protection,

and retribution—shape attention and information processing in complex social environments and thereby influence important down-stream behavioral decisions.

Research Approach

We plan 10 laboratory experiments designed to test hypotheses derived from our conceptual framework. Each experiment employs established research paradigms and methodologies used in social psychology and cognitive science; manipulates participants' self-protection, other-protection, and/or retribution goals; assesses individual differences in the chronic status of these goals; confronts participants with complex social scenes in which target individuals differ in their sex, age (combatant age or not), group membership (ingroup, outgroup, or outgroup ally), facial expression (angry or not), and/or possession of a weapon; and examines how these goals alter visual attention to, encoding of, memory for, and/or behavioral decisions about the different individuals in the scenes.

Accomplishments - N/A – New Start

Contributions to Basic Research

This research will make several important contributions: (1) it will theoretically link research literatures addressing how fundamental human goals affect information processing with ecologically inspired theories of motivation and cognition; (2) it will more specifically generate a framework for understanding how goals related to self-protection, other-protection, and retribution shape early-stage attention and interpretation of complex, information rich social environments, and thereby influence subsequent behavioral decision making; and (3) it will provide rigorous empirical tests of the hypotheses derived from this framework. In these ways, this research will expand upon the field's understanding of motivated social perception and cognition.

Potential Army/Military Applications

Our conceptual framework offers specific predictions about how individuals motivated by a range of social goals will differ in how they process complex social information and make behavioral decisions. It is thus highly relevant to understanding how a soldier's perceptual, cognitive, and decision making processes may depend, for example, on whether he or she is primarily concerned in the moment with self-protection, protection of a friend or comrade, retribution for an attack on one's country or the death a comrade, or the safety and well-being of innocents in the field. Specifically, this research should provide useful information and techniques for (1) selecting personnel into appropriate task roles (e.g., the research paradigms, or adaptations of them, should be useful for identifying those individuals most susceptible or resistant to particular goal-related biases), (2) identifying those individuals most in need of training to overcome such biases, and (3) designing training programs to mitigate such biases.

Future Plans

Our plans for Year 1 are: (1) to create the photo stimuli, goal manipulation films, and "video game" required to run our proposed experiments; (2) to begin Experiments 1 (exploring visual attention to heterogeneous arrays of target individuals), 4 (extending the findings of

Experiment 3), and 7 (extending the findings of Experiment 8) and (3) to begin and complete Experiments 3 (exploring rapid categorical "enemy/not-enemy" decisions) and 8 (testing hypotheses about how stimuli related to different motives interfere with one another).

An Integration of Motivation Theories

Contract #: DASW01-04-K-0001   **Contract Dates:** 12/12/03–12/11/07
Institution: The Hebrew University of Jerusalem   **PI:** Avraham N. Kluger
                                                  Liaisons: Trueman Tremble, SARU
                                                            Robert Solick, LDRU

Problem(s)/Research Question(s) – Does thinking about the basic challenges for human survival show us ways to integrate variety of motivation theories?

Technical Barrier(s) –Multiple well-accepted mid-range theories of motivation exist, most of which are related to each other and inform each other. However, these theories use different language and labeling and come from different research traditions that mask useful commonalities.

Significance/Impact for Basic Research – Recognize how scattered theories are related to each other, which may lead to a more parsimonious understanding of human motivation, and improve the communicability of knowledge.

Potential Transitions – Knowledge gained in this basic research may be usefully employed in:
- Various Army training programs
- LEADERSHIP: Developing leaders in a changing army (WP 103)

Overview

Consider what strategies humans can adopt to guarantee survival. Apparently, one winning strategy is sticking to what works, that is, maintenance of routines. Maintaining routines is advantageous because any routine, on average, guarantees survival. One can infer that maintaining routines guarantees survival because performers of non-adaptive routines are likely to be eliminated sooner or later by nature. Yet, this line of thought has one fatal flaw. If you only successfully maintain routines, sooner or later you will be eliminated by nature because once the environment changes you will be left without an appropriate behavioral repertoire to fit the new environment. So, if maintaining routines is fatal, what might be the alternative?

Perhaps, a strategy of exploration and constant change may be more adaptive: investing efforts in learning, exploring and experimenting is most likely to enable you to adapt to dynamic changes in the environment (food, mates, and social structures) and to help you optimally exploit the environment to guarantee survival. Yet, this thinking, too, has one fatal flaw. A strategy of experimentation is patently dangerous. One can infer that experimentation is dangerous by thinking about the probability that you will die either in an act of an experimentation or in an act of repeating a routine. Obviously, a tested routine is far safer than experimenting with the unknown. Thus, if you adopt an experimentation strategy you are likely to be eliminated by nature before too long.

Thus, rather than by choosing between maintaining-routines and change, managing a balance between these strategies may enhance fitness. To manage this preservation versus

change conflict, two systems might have evolved. One system might have evolved to maintain routines, using signals of pain to prevent deviation from routine. Another system might have evolved to explore the advantages of novel behaviors, using signals of reward to attract us to novel and successful change. Since the goals of these systems are in conflict they might have evolved as separate systems that compete within the organism for behavior monitoring and control. These systems may provide us maximum behavioral plasticity in the same metaphorical manner in which the muscles operate smoothly with two opposing (contracting and relaxing) forces. Indeed, multiple motivation theories seem to reflect similar concerns and offer a complementary picture of the processes involved in adaptation (Kluger & Ganzach, in press).

The thoughts about these two systems lead to multiple theoretical questions. For the purpose of this document, I report accomplishments in one research track that has both clear theoretical resolution and readily recognizable applied implications for the Army[1]. In this track, the theoretical question was "Do different theories reflecting preservation and change strategies, yield similar predictions?" To probe this question, my group considered how different theories will handle a practical question: What motivates people more – positive or negative feedback?

Research Approach

To demonstrate the viability of thinking about preservation and change strategies, a two-stage approach is taken. The first stage, the essence of this project, was to develop theory by reviewing existing theories, and searching for commonalities and discrepancies. The second stage, where feasible, was to empirically test specific hypotheses generated within each of these research programs. In the current report, the empirical tests were based on laboratory experiments.

Accomplishments

In this period, my group (Levontin, Kluger, & Van Dijk, under review) have explored the commonalities and discrepancies between two leading motivation theories, exposed discrepancies, and offered a reconcilation. This work is now composed as a theoretical paper which is now under a second revision for consideration for publication in a special issue on theory in the *Journal of Applies Psychology* (see brief review below). Also, data in initial support of the theory is now available (see Figures below).

Two leading motivation theories -- goal-orientation theory (Dweck, 1986) and self-regulation theory (Higgins, 1997) – both appear to reflect the strategies of maintenance versus change and yet are somewhat inconsistent. Dweck (1986), in her child development research, proposed that motivation can be guided by orientation toward one of two different classes of achievement goals: learning goals and performance goals. Individuals with learning goals seek to increase their competence, to understand or master something new. They view achievement situations as opportunities for acquiring new skills, extending mastery or developing and

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[1] In a second research track supported by this grant, I have shown (Kluger, Stephan, Ganzach, & Hershkovitz, 2004) that one prediction of prospect theory, which won Daniel Kahneman the Nobel Prize in Economics in 2002, is largely valid for a maintaince system but not for a change system.

improving ability (Ames & Archer, 1988; Butler, 1987, 1992; Dweck, 1986; Dweck & Leggett, 1988; Nicholls, 1984). The motivation that results from learning goals (even when faced with obstacles) is characterized with interest, enjoyment, positive affect, effort, and the assessment of performance progress relative to past performance. On the other hand, individuals with performance goals, seek to establish the adequacy of their ability both in their own eyes and in the eyes of others and to avoid giving evidence of its inadequacy. They view achievement situations as tests or measures of competence. The motivation that results from performance goals is characterized by concerns regarding normative ability, desire to achieve successful outcomes or to avoid unsuccessful ones relative to others, and an inclination to prove high ability by achieving success with little effort. The consequences of performance goals, when faced with obstacles, are helplessness, anxiety, negative affect, risk aversion and low persistence (Ames & Archer, 1988; Butler, 1987, 1992; Dweck, 1986; Dweck & Leggett, 1988; Nicholls, 1984). Thus, it seems that goal-orientation theory reflects both a maintenance strategy (performance goal) and a change strategy (learning goal).

Higgins' (1997; 1998) extended the basic hedonic principle - approaching pleasure and avoiding pain – and offered regulatory-focus theory that describes important differences in the processes through which people approach pleasure and avoid pain. Specifically, the theory proposes that people have two basic regulatory focus systems. One system regulates the achievement of rewards and focuses individuals on promotion goals, while the other system regulates the avoidance of punishments and focuses individuals on prevention goals. Thus, it seems that regulatory focus theory too reflects both a conservation strategy (prevention focus) and a change strategy (promotion focus).

Now consider predictions that can be generated by these two apparently similar theories. What motivates people more -- positive or negative feedback? Self-regulation theory suggests that under prevention focus negative feedback motivates more than positive feedback. That is, people that sense that their routines are failing will be highly vigilant to correct the recognized problem. In contrast, goal-orientation theory (Dweck, 1986) suggests that positive feedback motivates more than negative feedback when people hold performance goals (maintenance strategy). That is, people performing a complex duty (required to learn new complex procedures) can be debilitated by the news that they are failing or that they cannot maintain their expected organizational roles. To resolve these conflicting predictions the current work considered expectancy theory (Vroom, 1964) as a bridge. Expectancy theory suggests that motivation is determined by two antecedents: Expectancy to succeed in the future (E) and valence (importance to oneself) of the outcome (V). The predictions of goal-orientation may pertain largely to feedback-sign effects on belief that one can succeed in the future (E) while the predictions of regulatory-focus theory pertain largely to feedback-sign on urgency to resolve the problem (V). Hence, our theoretical resolution suggests that:

H1: When maintenance strategy drives behavior (prevention focus or performance goals) failure will both increase V (drive sensed as an urgency to solve the problem) and reduce E (belief in one's abilities).

This prediction of what happens when people receive feedback and are operating with a maintenance strategy is presented in the graph below. Following this graph are data in support of this model.

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Figure 1
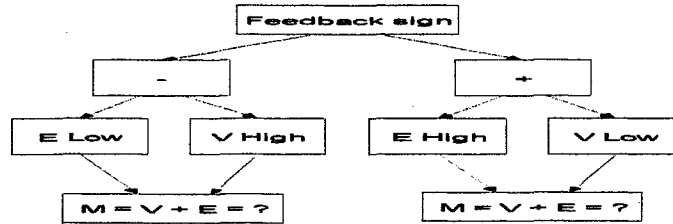
To test our proposal for theoretical reconciliation, we ran an experiment. In the experiment, we measured participants' (N = 122) levels of E and V before and after bogus failure (N=122). We randomly assigned participants who performed an anagram task to three motivational manipulations: (a) Goal orientation (performance goal) was manipulated using task instructions (Nicholls, 1984; Steele-Johnson et al., 2000); specifically, participants were instructed that performance on memory tasks reflects basic cognitive capacities and that the higher their underlying cognitive capacities are, the better their performance on such a task should be; (b) Regulatory focus (Prevention focus) was manipulated using the reward for participating - participants were told they might lose some money or not (Shah, Higgins & Friedman, 1998). They were told that they are expected not to miss more than 10% of all possible words. Although payment for participating in the experiment is 10 Shekels it is possible for them to lose 5. They would not lose five shekels if they missed 10% or less of all the possible words, but they would lose five shekels if they missed more than 10% of all the possible words; and (c) Control group participants did not get any information regarding the task. Results (see Graph below) were supportive of our hypothesis. That is, eliciting either performance goals or prevention focus (presumed theoretically similar variables) both increased valence and decreased expectancy.

Figure 2
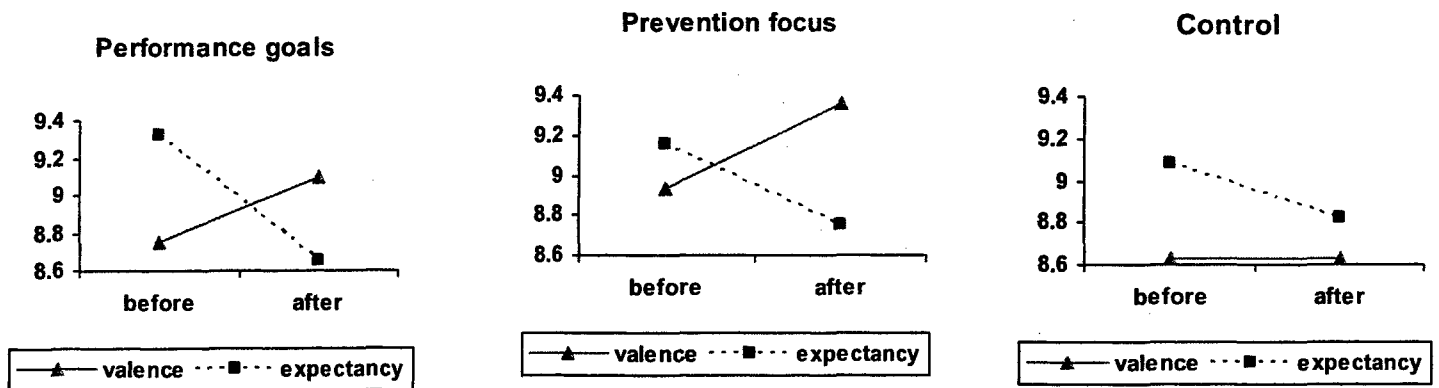
Contributions to Basic Research

The current work demonstrates that thinking about strategic challenges for survival helps to organize apparently unrelated theories into one conceptual framework that facilitates our understanding of motivation and reactions to feedback.

Potential Army/Military Applications

If our hypothesis is further validated, our theory exposes a serious difficulty in applying performance appraisal in the military. The difficulty stems from the expectation that the effect of failure on expressed motivation and actual performance is likely to be a combined effect of feedback on urgency (valence) and on belief (expectancy). If we assume that in the military most performance evaluations are administered in an organizational context in which avoiding harm (maintenance) is emphasized over searching for opportunities (change), then we can predict that the motivational effects of feedback on the force on average are going to be nil due to the opposite effects that feedback sign has on the two antecedents of motivation (valence and expectancy). This call for a review of the goals of performance appraisal systems in the military and search for alternatives that appear both theoretically and empirically more effective. Whereas the current work imply risks for the Army in using feedback, the future plan of my groups are geared towards developing theory-based techniques to enhance performance via FEEDFORWARD. Initial applications in various organizations suggest that these products will be highly relevant applied alternatives that can be used in the Army

Future plans

To continue developing a theory, I seek to build it in light of a practical question: How one should use feedback, performance appraisal, etc. in organizations? The bulk of the data suggests that systems such as performance appraisal are not very effective. To search for alternatives, the general theory will be expanded with the applied problem in mind.

Several motivation theories suggest that humans, in addition to routine maintenance versus change conflict, another set of motivationally conflicting challenges: within species competition versus cooperation. This conflict appears to be found in various theories under different labels such as, need for power versus need for affiliation; individualism versus collectivism (e.g., Colquitt, Noe, & Jackson, 2002); agency versus communion (e.g., Brunstein, Schultheiss, & Grassmann, 1998; Fournier & Moskowitz, 2000) and dominance versus love (e.g., Tracey, 1994; Tracey, Ryan, & Jaschik-Herman, 2001). Thus, it appears that this second strategic conflict is also very basic to human behavior. In the next period, I plan to explore how this second conflict modulates the first one. This exploration will be geared both towards further theoretical development and towards developing new applications in organizations.

At the practical level, I am working on developing tools for organizational change predicated on the (to be tested) assumption that evoking both promotion focus (drive to change) coupled with strong feeling of belongings (camaraderie) produce a mental state that is most amenable for fast learning and growth. To create a sense of both belongings and promotion, I propose that feedback interventions be preceded by FEED-FORWARD interventions. In feed-forward, people (organizations) are coached as to express their dreams, ideals and wishes. After stating dreams, a plan with goals and means is set to achieve those dreams. Next, people answer

the following question: "Imagine that you applied your plan, will it take you to your dream?" If one discovers a discrepancy between the imagined future and one's dreams the process is repeated as to revise the means, goals, or even the dream. When feed-forward yields no discrepancy the process is complete. This mental exercise may help align deep-seated motivations with explicit goals; hence, discovering the shortest route to the dream fulfillment, and guaranteeing the creation of strong-goal commitment. Feed-forward alone may provide positive and lasting (transformational) effects. Such interventions may work because they simultaneously induce a strategy of change coupled with a strategy of cooperation (with the consultant, organization).

International Military Education and Training: A Sociological Analyses

Contract #:1435-01-01--31151   **Contract Dates:** 06/01/2001-11/30/04
Institution: Northwestern University   **PI:** Charles Moskos

Overview and Research Approach

International Military Education and Training (IMET) is the cornerstone of professional military education for non-American officers in the United States. At the acme of IMET are those international officers (IOs) who attend American war, command and staff colleges – some 400 annually. Many of these are destined to become senior officers in their home militaries.

This report is based on personal interviews with 82 IOs at the senior military schools in the United States in each of the services. Interviews were also conducted with American students and staff members of these same schools. Issues covered include an overview of the IMET experience from the IO viewpoint such as housing, family, sponsors, friendships, field trips, classroom atmosphere, and curriculum. The mutual perceptions of IOs and fellow American students of each other were also examined.

The overriding finding is that the IMET experience is typically viewed in very favorable terms. Not only do IOs become incorporated into American professional military education, but American students also gain a unique military learning experience by interacting with IOs.

In sum, IMET is a key resource serving long-term American security and one that deserves utmost support from the national policy-making community.

Accomplishments

The military senior command in the Joint Chiefs of Staff has been briefed on the findings of the research. Steps are being introduced to make medical insurance more widely available to family members, rethinking the nature of security classification for IOs, and, more tentatively, incorporating content on multinational issues in the curriculum of the war and staff colleges. To a major degree, these initiatives were influenced by the research reported herein.

Contributions to Basic Science

The findings are based on a qualitative methodology; namely, personal interviews with IOs and American students. The collected data are directly relevant to research on generic multinational institutions, e.g. multinational political bodies, multinational corporations, non-government organization. In particular the research findings bear on the relative balance between cultural differences and personality variables in multinational interaction and relations. In particular, the research pertains to Gert H. Hofstede's on the cultural consequences of international differences in work-related values.

The data also indicate that models of international cooperation must not rely only on econometric analyses and "rational man" premises. Social psychological and cultural variables are central to any understanding of international military cooperation. The eminent psychologist Leon Festinger developed a "comparison theory" in the 1950s. This is to say that humans

evaluate themselves and their relations with others not so much by objective standards, but by comparisons with people around them. Similarly, the concept of "reference groups" greatly enlightens studies of international relations. This is to say that people get their cues from meaningful groups rather than a generalized other.

Potential Army/Military Applications

International military cooperation is a key element in military effectiveness. The significance of effective coalition warfare can scarcely be exaggerated. This is especially so since the events of 9/11 and the subsequent war against terrorism. The findings have special relevance for furthering cooperation of non-American militaries in mutli-national military missions. Indeed, the relationship between American military officers and those of other nationalities can be a major factor in fostering pro-Americanism in coalition missions.

At the more immediate level, the research made concrete suggestions on how to improve IOs integration into the American milieu, both academically and socially. Certain problem areas were analyzed with attendant recommendations for improvement. These include: (1) making medical insurance available to the family members of all IOs; (2) decreasing the material unavailable to IOs because of security classifications; (3) adding curriculum content on multinational operations and current international issues; and (4) extending more effort to incorporate the spouses of IOs into the American social scene.

Future Plans

Follow-up research will be conducted at multi-national headquarters to ascertain what steps can be taken to improve international military. This research will also enable us to make informative comparisons of American-IOs in other settings. As always, the principal investigator will conduct research on sociological topics requested by senior military officers and Defense Department officials.

Comprehension and Memory of Spatial and Temporal Event Components

Contract #: DASW01-02-K-0003   **Contract Dates:** 05/01/02-04/30/04
Institution: University of Notre Dame   **PI:** Gabriel A. Radvansky
                                                Liaison: Tonia Heffner

Problem(s)/Research Question(s) – How do people differ in the ability to detect and process changes in spatial and temporal event information for on-going situations?

Technical Barrier(s) – Models and theories of event comprehension and memory are only currently emerging.

Significance/Impact for Basic Research – Understanding how people monitor and update changes in situations will allow for more developed models of how people comprehend and remember information about events in the world as they are unfolding.

Potential Transitions – Knowledge gained in this basic research may be usefully employed in:

- FUTURE-TRAIN: Techniques and Tools for C4ISR Training of Future Brigade Combat Team Commanders and Staffs (WP 211).
- MEASURE DIGITAL: Defining and Measuring Digital Skill Proficiency (WP 234).
- Future Force Warrior Training (WP 215).
- VICTOR: Virtual Individual and Collective Training for Future Warriors (WP 233).
- SELECT21: Selection, Classification, and Performance Metrics for the Future Force (WP 257) and ATO: IV.HS.2002.01.
- Perform M21: Performance Measures for 21st Century Soldier Assessment (WP 104).

Overview

When people are presented with information about events, in order to successfully comprehend and remember that information, they need to be able to deal with the changes that occur. Situations and events are dynamically changing over time. As such, people need to identify when these changes have occurred, and update their understanding of the event in a way that takes these changes into account. How do people keep track of these changes? Are some people better at monitoring these changes? What makes them more efficient?

There are many components of a situation. In an overview of research on event memory and comprehension, Zwaan and Radvansky (1998) delineated major dimensions that people monitor, including space, time, entities, causality, and intentions. Recent work by Radvansky and Copeland (2000; 2001; 2004; Radvansky, Copeland, Berish & Dijkstra, 2003; Radvansky, Copeland & Zwaan, 2003; Radvansky, Zwaan, Curiel & Copeland, 2001) has shown that the ability to monitor these changes is not related to general mental capacity such as memory span (i.e., the amount of information that a person can hold in mind at one time). Instead, it appears to involve mental processes and abilities that are specific to understanding situations and events.

- The focus of this project is on changes in space and time. That is, when there has been a shift in space (an entity is in a new location) or time (a significant period of time has passed), people need to know what elements from the previous

situation are still relevant and what are not. For example, if a person learns that someone has traveled from New York to London, after noticing this change, the person needs to mentally keep track of the fact that the traveler had brought a computer disk with classified information with her, and that she has left behind her book of contacts. Although space and time are basic components of the world, people do not always actively monitor and update their understanding of events after changes in space and time (Zwaan & von Oostendorp, 1993; Zwaan, Radvansky, Hilliard, & Curiel, 1998).

- We assess spatial and temporal updating using our knowledge of how people use mental representations called mental models. Our hypothesis is that people proceed through a series of stages.

  o During the first stage, a person detects a change in space or time.
  o During the second stage, a person creates a mental representation that takes into account that new spatial location or time period. The ability to engage in this second stage depends on the success of the first stage.
  o Finally, during a third stage, the new mental model is created that coordinates the relevant information from the old situation. Specifically, old elements that remain relevant should be maintained in the new mental model. Furthermore, elements that are no longer relevant should not be included in the new model. By looking at the success of people to track and update this information we hope to be able to identify the circumstances in which people are able to do this correctly, and to identify ways to correct any deficiencies in doing so.

- More recently, we have extended our efforts beyond language comprehension to interactive experiences with desktop virtual reality environments. We are looking at how the spatial updating effects that have. been observed in language comprehension extend to actual experiences with events. This line of work has looked at two issues.

  o The first is the idea that when there are changes in spatial location, information about entities that are carried over to the new location should continue to be available in memory, whereas information about entities that are left behind in an old location should become less available (e.g., Glenberg, Meyer, & Lindem, 1987).
  o The second is the idea that as a person moves through a space, the further away things are from the current location, the less available information about that entity should be (Morrow, Greenspan & Bower, 1987). This is called a spatial gradient. By looking at how changes in space during an on-going event are disrupting thinking. By knowing this we can target those aspects of the situation that are giving people the most trouble, allowing training and technology to target these deficits.

Research Approach

In some of our experiments, people were given a series of narratives to read, one sentence at a time. Reading times were recorded. The length of reading times gives an index of reading difficulty. Ideally, when an event shift occurs, people will exert more effort to update their understanding of the situation, and reading times will increase. Thus, it was expected that a noticed change in space or time would show a slow-down in reading times.

In addition, in some expeirments, reading was interrupted with probe words. On critical trials, these probe words assessed the ability to update event understanding. The task was to indicate whether these words referred to the narrative. The expectation was that people would repond faster when they referred to an element that was part of the current situation, and slower when it did not. Our key interest was in the relation between the various measures, which assessed different stages of event updating. Specifically, people who were successful at earlier stages should be more successful at later stages.

In our work using virtual reality, people navigated through virtual reality environments with some goal in mind. In some cases the goal was to move objects from room to room. In these cases, we would look at the availability of information about an object as a function of whether it was currently being carried, or whether the object had been put down and was now in a different room from the person. This was done by stopping the progress in the environment and presenting people memory probes consisting of object names. The task was to indicate whether the object was one that was currently being carried, one that was just set down, or some other object.

In other cases, people memorized the layout of a building prior to virtual reality navigation. This was done to assess both the influence of prior knowledge, as well as spatial distance, on the availability of event knowledge. After memorization, people moved about in different locations within the virtual reality environment. At different points, they made location judgements about various objects.

Accomplishments

The results of our experiments are consistent with our hypotheses. Specifically, the degree to which people show effects of situation model updating at later stages is contingent on their success at earlier stages. The data from one of our our experiments looking at the updating of temporal event information is presented in the figures below.
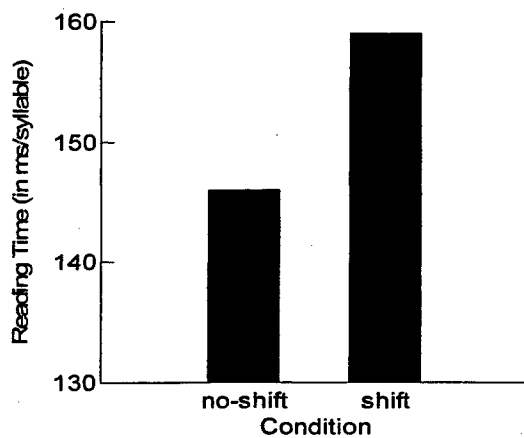
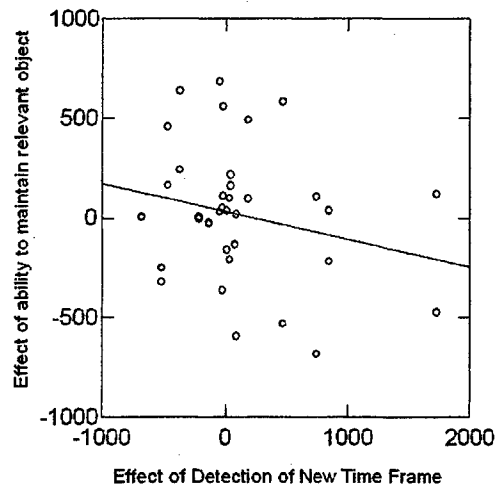Figure 1. Reading times (in ms / syllable) for sentences that either do or do not contain a temporal shift.

Figure 2. Relation between the effect of the detection of a new time frame, and the effect of response times to objects maintained across temporal boundaries.

The results of this work support our predictions. Moreover, the ability to update one's understanding of the event in one area is related to the ability to update in other ways.

We also have some data from virtual reality studies looking at spatial updating. What we have observed is that there are two aspects of interaction with a situation influences the ability to monitor what is going on. First, things that people are currently associated with or carrying are more available than things that have been just set down, even if the person is still in the same room with that object. The second is that when people move from one spatial location (room) to another, information about the on-going event is disrupted. What is most interesting is that knowledge of even what one is currently carrying in the new spatial location is disrupted after a spatial shift. This is shown in the figure below.
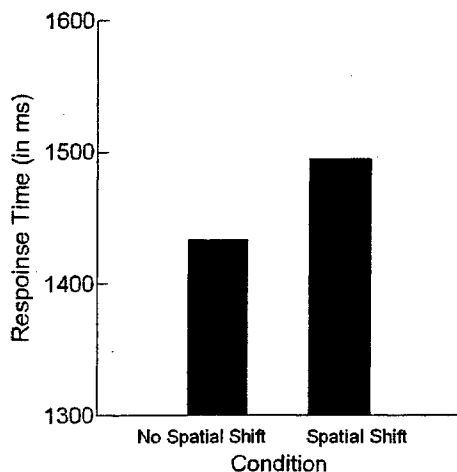

Figure 3. Response times (in ms) to object name probes as a function of whether people had just made a spatial shift or not.

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Our studies with virtual reality have also found that when people move from one room to the next, even in a well-known area, information about the room just left drops in availability as people mentally work to understand the new situation. The figure below shows the ability to identify information about objects when a person has moved from one room (*Source*) through a second room (*Path*) and ending up in a final (*Goal*) room. The data also present the availability of objects from some *Other* room. People are slowest for objects from the room they have recently moved from. This suggests that shifts in location disrupt the ability to retrieve information about recent event components.
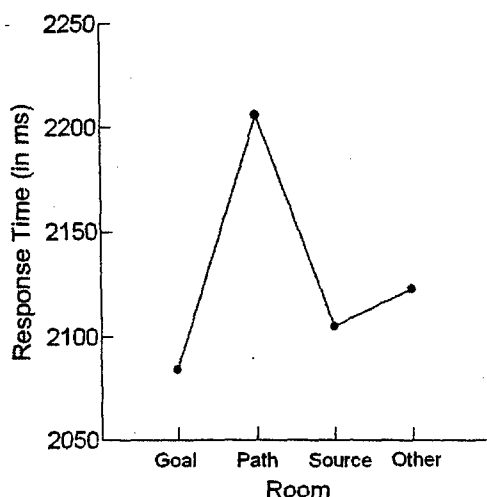

Figure 4. Response times to memory probes (object name pairs) as a function of distance from the subjects' current position in the virtual environment.

Contributions to Basic Research

This project will provide us with a more advanced understanding of how people track changes in descriptions of situations that occur in the world. This research follows several recent developments in mental model theories and extends them by looking more precisely and the stages that are involved in updating understanding. This more precise analysis will allow for a clearer understanding of how people comprehend, monitor and remember changes in events and situations in the world based on the information they receive. From these data, we hope to develop a means of identifying when people are having trouble updating event information, and provide a more targeted means of correcting those problems.

Potential Army/Military Applications

The potential applications of this research for the Army are in the areas of training and system interfaces. In the area of training, this research will provide insight into the specific difficulties that people have updating their understanding of events. Knowing in what ways people have trouble tracking changes in space and time will allow for the development of procedures that would directly target such deficits. In addition, because the modern soldier needs to interact with sophisticated technologies that involve tracking various entities through time and space (whether they be enemy forces, one's own supplies or friendly forces), knowing

the capabilities and limits of human event comprehension and memory will help in the design of these systems. Spatial and temporal information that is readily tracked by people would need either minimal or no feedback from the system. However, those aspects of spatial and temporal processing that are more difficult would be a higher priority for that system, in terms of augmenting the soldier's current capabilities.

Future Directions

Currently we are continuing to follow two lines of experimental inquiry. The first is that we are continuing to explore the ability of people to update spatial and temporal information about a situation that they acquire from descriptions of events. More specifically, we continue to look at people's abilities to detect spatial and temporal shifts, to create new frameworks for when such shifts occur, to maintain information that continues to be relevant after an event shift has occurred, and finally, to remove information from the current stream of thought that is no longer relevant because of the event shift. The other line continues looking at the ability to process spatial shifts, and how these spatial shifts affect the ability to monitor other aspects of an event. This is being done by having people travel through desktop virtual reality environments. The aim of this line of research is to look at how discoveries in language-based understand of situations and events can be extended to more realistic situations. The desktop virtual reality environment is helpful because it allows us to construct various aspects of a spatial environment to adequate test their influence on thought.

Development and Empirical Evaluation of a Theory of Socially Competent Job Performance for United States Army Junior Commissioned Officers

Contract #: DASW01-02-K-0002 **Contract Dates:** 5/1/02–8/31/04
Institution: Personnel Decisions Research Institutes, Inc. **PI:** Robert J. Schneider
Liaison: Peter J. Legree, RACO

Problem(s)/Research Question(s) - What is the nature, and what are the causes, of socially competent work behavior in junior commissioned Army officers?

Technical Barrier(s) – Neither a well-developed theory of socially competent work behavior nor adequate measures of social knowledge and motivation are available.

Significance/Impact for Basic Research - This research resulted in the first comprehensive theory of socially competent work behavior ever developed and an innovative and valid measure of social knowledge.

Potential Transitions -- Knowledge gained in this basic research may be usefully employed in the following ARI work programs and projects:

- SELECT21: Selection, Classification and Performance Metrics for the Objective Force (WP 257)
- Accelerating Leader Development (WP 269)
- LEADERSHIP: Developing Leaders in a Changing Army (WP 103)
- Perform M21: Performance Measures for 21st-Century Soldier Assessment (WP 104)
- Assessing and Developing Leaders for Special Operations Units (WP 218)

Overview

Social competence is critically important for Army officers. The purpose of this research was to enhance understanding of what makes a junior commissioned officer socially competent. To do this, we built on previous theoretical work by Hunter (1983), J. P. Campbell (1990), and Motowidlo, Borman, and Schmit (1997) that focused on understanding job performance at a more general level. This earlier work has two things in common: (1) one must have a clear understanding of the job performance that is to be predicted, and (2) abilities, personality traits, and other individual-differences characteristics predict job performance primarily or exclusively through performance-relevant knowledge. Our research used the evolving framework developed in this earlier work, but focused specifically on the interpersonal aspects of job performance, something that had not been done previously. A rigorously developed and tested theory of social competence would not only facilitate selection, classification, and training of junior commissioned Army officers, but would also add significantly to the evolving understanding of job performance.

Research Approach

We began our work by specifying a general theory of the types of characteristics that should predict socially competent job performance. Components of the theory that we believed

would predict social job performance were: interpersonal personality traits (for example, dominance and charisma), social intelligence, general intelligence, social knowledge, and social motivation. Then, we identified the major social job performance dimensions. The next step was to develop measures of each attribute in our general theory of social competence. Existing measures were obtained where possible, but it was necessary to develop a new social knowledge test (SKT), social motivation measure, and social job performance measure.

The SKT was based on social scenarios derived from our social performance model. These were refined and elaborated in workshops with subject matter experts (SMEs), and the knowledge requirements for each scenario (e.g., what goals should one have? What would be effective and ineffective ways to achieve those goals?) were fleshed out in additional workshops. We used this information, supplemented by other information available on military websites and other relevant source materials, to create scripts for each scenario for videotaping. The SKT consists of 20 such scenarios. Examinees view a scenario and then write down all the effective and ineffective behaviors they can spot. Responses are thus open-ended, as opposed to multiple-choice or some other format specifying response options from which to select. We also developed a measure to assess people's motivation to display each aspect of social performance in our social performance theory. Finally, we developed a social performance measure covering the various dimensions that we found to constitute socially competent job performance. The examinees' social performance was rated by those who interacted with them often enough to know their social performance well.

We tested our theory by administering instruments measuring its various components to advanced (3rd-year and beyond) ROTC cadets and midshipmen. We regarded these individuals as good surrogates for junior commissioned officers, since they are in training to become junior commissioned officers. We developed and tested five separate social competence theories (all of the same general form) for each major dimension of social job performance that we identified. This was important because different things predicted different aspects of social performance. The study design was based on examining correlations between study variables and using advanced statistical techniques to determine whether the data corroborated our theoretical predictions.

Accomplishments

This research yielded several important accomplishments. First, our approach to measuring social knowledge turned out to be quite viable. We were able to get SKT scorers to agree in their evaluations of SKT responses, despite the fact that those responses were open-ended and, in some cases, required significant judgment to score. More importantly, examinees' overall social knowledge scores showed substantial correlations with three out of five social performance dimensions: Effective Supervision, Social Presence, and Interpersonal Sensitivity, all of which are instrumental to success as a junior commissioned Army officer. Second, our results corroborated many of our theoretical predictions. The general form of our theory, which incorporates those predictions, is shown in Figure 1.

Figure 1. Hypothesized General Form of Theory of Socially Competent Job Performance
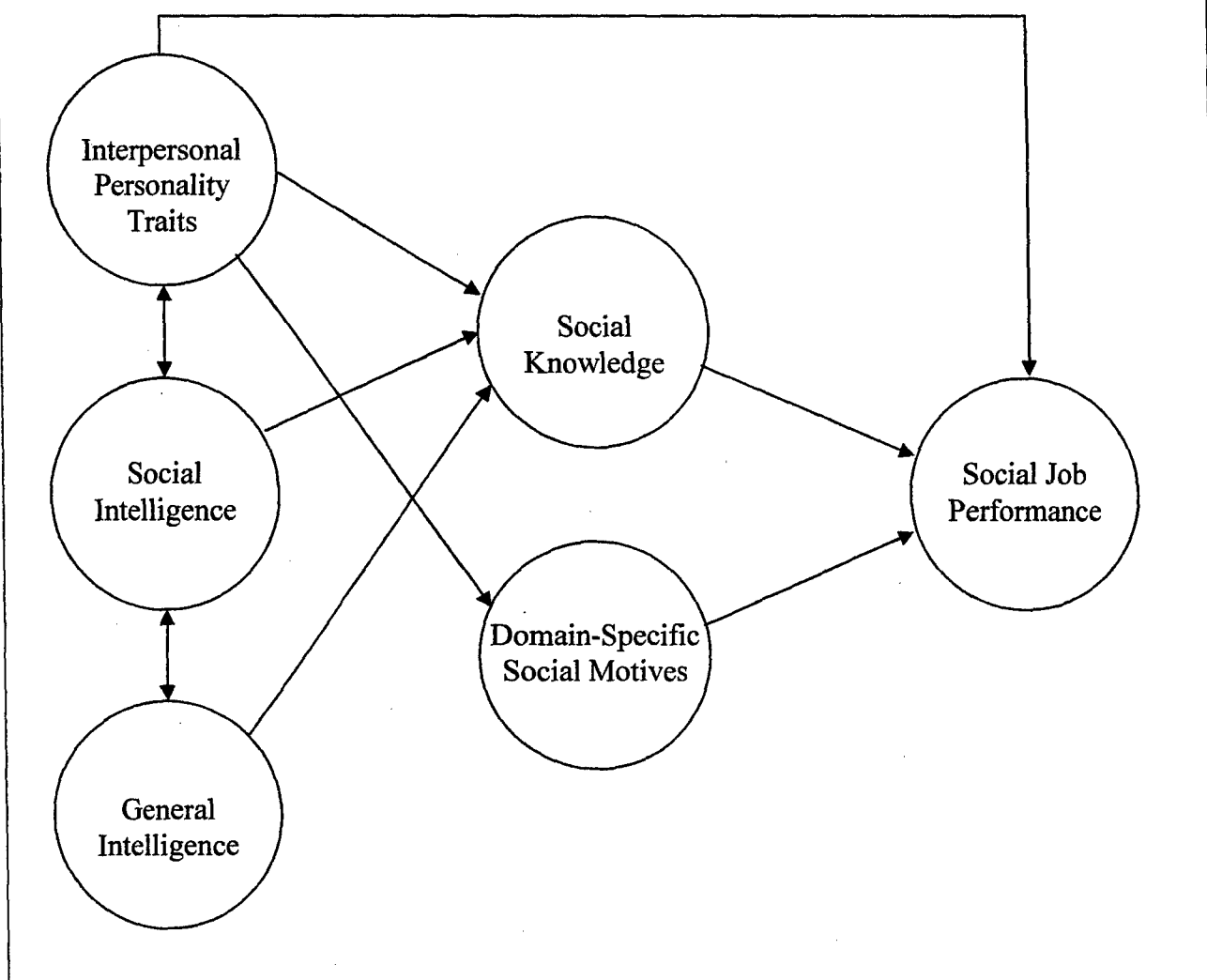
Space limitations preclude a full description of our results. We note, however, that our key hypothesis, that social intelligence would predict social job performance only through its relationship to social knowledge, received support for three out of five social job performance dimensions, as did our prediction that cognitive ability would predict social job performance through its relationship to social knowledge (though in one case it also predicted social job performance independently). These results make sense in light of the fact that social intelligence and general intelligence should cause socially effective work performance only if they yield knowledge of what to do during social interactions that play out in social scenarios.

Contributions to Basic Science

This project advanced understanding of interpersonal job performance in several important ways. We identified the major dimensions of social job performance, and formulated and tested a family of theories explaining differences in those social job performance dimensions. Our theoretical predictions received significant support in our data.

Methodologically, we showed that a scenario-based approach to social knowledge testing administered on video using an open-ended response format with right and wrong answers is viable. This type of measurement is more realistic than paper-and-pencil tests with response options already provided. This project also yielded several useful products, including the SKT and the social performance measure we developed based on our social performance model. We also developed a social motivation measure, though this will require further research and development work before it can be used operationally since it did not conform to certain theoretical predictions.

Potential Army/Military Applications

A relatively direct application of our research would be to take the social performance measure we developed for this project and use it as the basis for development of a computerized assessment and development tool. This could, for example, be adapted for use in the "Accelerating Leader Development" project. Our social performance instrument could be placed on an Army website, and Army leaders could then receive self-assessment-based feedback, or feedback on the same social performance dimensions from their superiors, peers, and/or subordinates.

The SKT developed and validated as part of this project could be used in a variety of ways. For example, the SKT's scoring key provides a wealth of information about social tacit knowledge necessary for effective interpersonal leadership among junior commissioned Army officers. As such, our results would fit well into projects such as "Developing Leaders in a Changing Army." Among the stated objectives of this project is "establishing an empirical link between measures of social tacit knowledge and performance outcomes." Data from our project can be used to address this issue. Our results could also be used to *develop* social tacit knowledge by adapting our SKT for use as a training tool. This also seems consistent with the "Developing Leaders in a Changing Army" Project. For example, the 20 video-based interpersonal scenarios in the SKT could be placed on DVD. After responding to each scenario (or the entire SKT), the scenarios could be repeated for trainees, with a voiceover that identifies the targeted social behaviors and explains why they are effective or ineffective.

A more ambitious training-related application would be to pause the videotaped scenarios in the SKT at critical points, require that the examinees assume the role of one or more characters in the scenarios, and have them say, in "real time," what they believe the characters should say at those junctures to be effective. A camera and microphone could be placed on the examinees at the computer stations where they would be taking the test to create an audiovisual record of their responses. We could then create sample audiovisual responses spanning the range of effectiveness levels and create audiovisual behaviorally anchored rating scales (AVBARS), whereby different videotaped performances would be calibrated to different effectiveness levels. These AVBARS could be used as a self-development tool by showing officers their performance and comparing it to different levels of performance based on the AVBARS. If used for formal training, trainers could administer the AVBARS to trainees and score their audiovisual responses to assess their training needs and plan training interventions. Learning points for training programs could be derived from differences in various AVBARS levels.

These results could also be extended to selection and training of Army recruiters. This is a job that requires significant interpersonal knowledge, skill, and ability, since recruiters' ability

to appeal to potential recruits and sell the Army lifestyle determines their success. Some of our predictors may add value to selection systems for these recruiter jobs. In addition, the methodology we used to develop SKT scenarios could be applied to develop recruiter-specific scenarios, with associated scoring guidelines that target effective and ineffective recruiter behaviors within those scenarios. This would be relevant to projects such as "RECRUITER: Improved Screening Tools for Recruiters and Station Commanders."

Final Summary

In this project, we formulated and tested a theory of socially competent job performance for junior commissioned Army officers. We also developed an innovative measure of social knowledge, and demonstrated the viability of that approach to social knowledge testing. Aside from demonstrating the validity of the SKT, our most striking result was that, for three out of five social performance dimensions, social intelligence influenced socially competent job performance only through its relationship with social knowledge, just as our theory predicted. Our results indicate that interpersonal personality traits, social intelligence and social knowledge all predict important aspects of junior commissioned Army officer job performance. They also establish that general intelligence is predictive of several aspects of interpersonal job performance.

The primary implication of this research for the Army is that measures of social intelligence and certain interpersonal personality traits should be incorporated into selection and classification systems for junior commissioned Army officers. In addition, since social knowledge will be more predictive of social performance than social intelligence, it should be considered seriously for selection/classification and training applications.

Having demonstrated the importance of social knowledge to junior commissioned officer job performance and the viability of our social knowledge measurement approach, we recommend that our SKT be adapted for use for other Army ranks, and for specific occupational specialties involving significant interpersonal interactions. For example, with some adaptation, the SKT could be generalized to NCOs. It could also be adapted for use with higher-ranking officers, where understanding of more sophisticated organizational politics becomes more important. Similarly, new scenarios could be developed for occupations such as recruiters, medical and counseling personnel, and special operations unit leaders, among other possibilities.

Future research in this area should seek to develop measures of social skills (using instrumentation that does not rely on self-report) and evaluate whether the type of social knowledge measured by our SKT influences social performance only through social skills. In addition, social self-regulation should be incorporated into our social competence theory. For example, how are social goals maintained in the face of initial failures to translate them into effective socially performance?

Social Structures Affecting Army Performance

Contract #: DASW 0100 K 0016
Institution: The University of Maryland

Contract Dates: 8/17/00-12/31/04
PI: David R. Segal
Co-PI: Mady Wechsler Segal

Problem(s)/Research Questions - What are the social structures, social processes and social psychological characteristics (e.g., attitudes, values) that lead young Americans to enter the armed forces as enlisted personnel or through officer accession programs?

Technical Barriers - Our knowledge of the structure of youth attitudes relevant the military service is not well developed, and while these attitudes have been shown to change significantly over time, the change processes are not well understood.

Significance/Impact for Basic Research - Identification of attitude organization and change processes among young adults will help us better understand the dynamics of this early stage in the life course and how they relate to subsequent behavior in adult life.

Potential Transitions - Knowledge gained in this research may be usefully employed in:
- Our Army's recruitment processes
- Our Army's officer accession processes
- Our Army's understanding of the needs of soldiers and their families
- Our Army's ability to manage an increasingly diverse military force

Overview

In a democracy, the armed forces reflect to a considerable degree the society they defend, and members of the armed forces participate in other social institutions as well. The intersection of the military and its host society, including other social institutions such as the family, the labor market, and the educational system, is an important component of both democratic civil-military relations, and of military effectiveness. How do changing attitudes among young Americans toward military service, work in general, and family formation and roles affect our ability to recruit and field an effective military force? Have trends in expectations among young Americans regarding whether they will serve in the armed forces affected our ability to recruit? What role do patriotic versus materialistic motivations to serve play in the kinds of soldiers we recruit? How do educational incentives figure into these motivations? Such incentives have been conceptualized alternatively as compensation in kind to reward patriotic service, and as direct economic incentives. Do young Americans who elect to serve in the armed forces seek different characteristics from their work than their peers who enter the civilian labor force or go to college after secondary school? To what extent do they feel that their desires to start families are compatible with military service? Since a larger proportion of the current young adult generation in America aspires to collegiate education than ever before, how does military service fit into the life plans of this generation? We seek answers to questions such as these to better understand the linkages between the armed forces and society in America. We build on theories that view the military in America as **a part of** rather than **apart from** society.

Research Approach

Much or our research involves the collection and analysis of survey data on a range of populations, civilian and military. Our current efforts draw upon: an ongoing program of research on the attitudes of high school seniors (the Monitoring the Future program) that has involved surveys of every high school graduating class since 1975 with follow-up surveys of sub-samples for fourteen years after graduation; a recent survey of the entering class at a federal military academy that included questions asked more broadly of young civilians participating in the Monitoring the Future survey; and a recent survey of first-term American soldiers serving in infantry units that sought to measure their recollections of their expectations for service while still in high school, the factors that motivated them to enlist, and their sense of identification with military roles compared to other social roles they played, such as parents and church members.

Accomplishments

Our research has contributed to our understanding of why some high school graduates elect to enter the military rather than pursue alternative post-secondary school activities such as college or civilian employment. We have documented a downward trend in the expectations and desires of high school seniors to serve in the armed forces, making the military more dependent on young men and women who had other plans. Most recently, we have explored the structure of various motivational factors that bring people into the military, and how these related to whether young men and women had expected to join the armed forces. Earlier research had suggested two general sets of motives: those rooted in patriotism or a desire for adventure, and those rooted in economic need. Our analysis suggested a more complex structure. Data from our first-term infantrymen confirmed that the most important set of motivators reflected a desire to serve, patriotism, a desire for adventure or challenge, and a desire to be a soldier. We call this our institutional factor. We also confirmed a job-oriented set of motivators, including a need to support one's family, a situation of economic crisis, and the absence of other or better job options. We call this our occupational factor. However, more powerful than the occupational factor was a set of motivators reflecting plans for the future, including a desire for a military career (which portends long-term retention), and a desire to get money for college (which portends separation from service once educational benefits are earned). We also identified a factor based on *monetary* issues independent of the *occupational* motivations described above. These monetary issues included joining because of an enlistment bonus, and needing money to repay college loans.

Only the institutional factor and the plans for the future factor were significantly related to whether soldiers had anticipated joining the military while they were still in high school. Those with such anticipation we call high propensity soldiers, while those without such plans we call low propensity soldiers. As shown in Figure 1, the high propensity soldiers report being strongly motivated by patriotic/adventure seeking factors, and by military service being compatible with their long-term plans, and placed little importance on the need for a job or for money. For soldiers who had not anticipated serving, by contrast, motivations rooted in patriotism, adventure, and future plans were unimportant. They placed greater importance on motivators reflecting the need or desire for a job or money. As expectations for military service continue to decline among high school seniors, the military will become increasingly dependent on low propensity soldiers. It remains to be seen how Army performance and effectiveness is
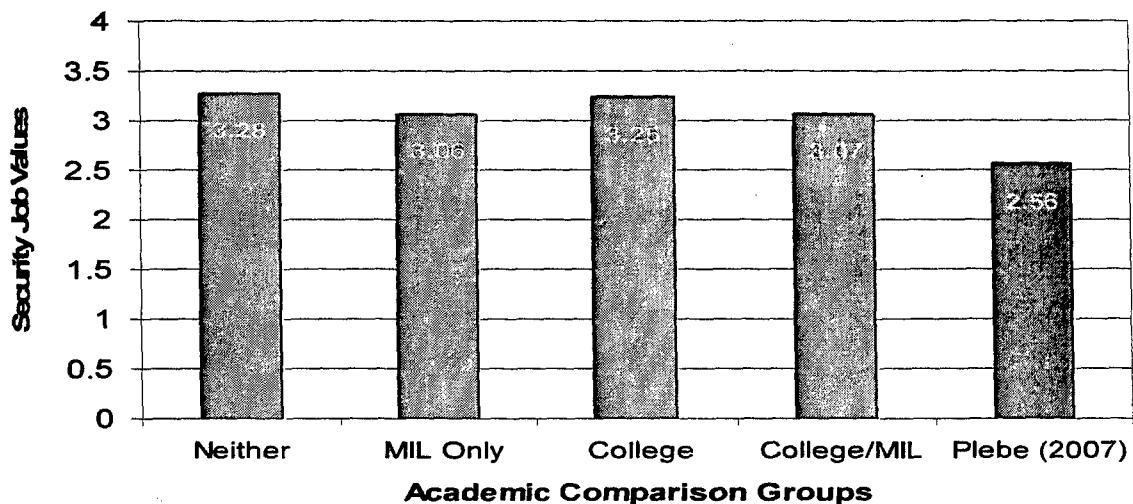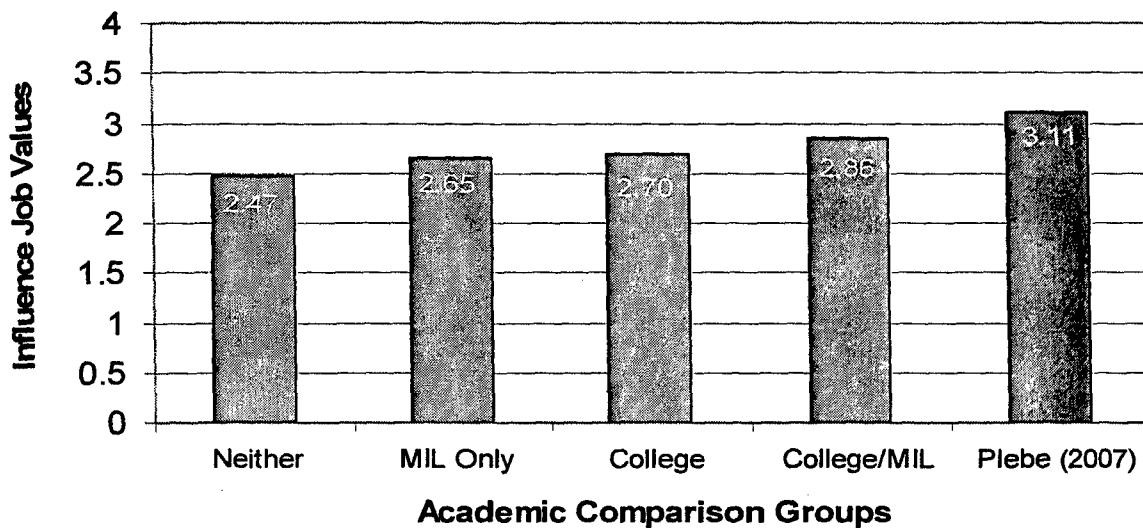
affected by having increasing proportions of soldiers serving because they need the work or need the money.

Figure 1. Enlistment Motivation by Propensity to Serve
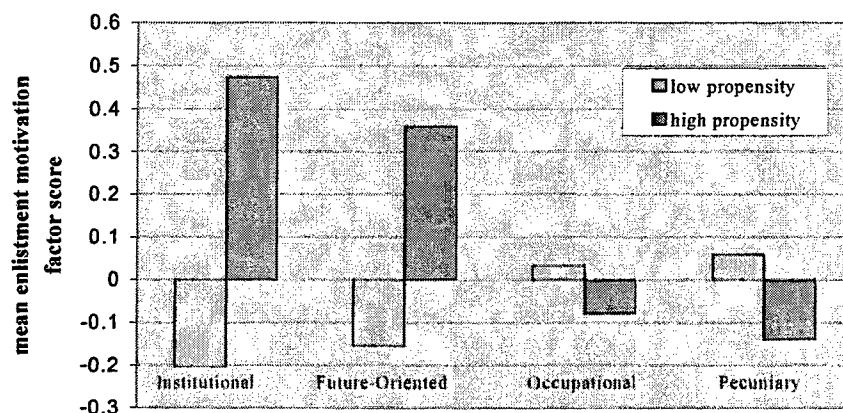
In our research on the job attitudes and values of American youth, we confirmed the existence of six clusters of job characteristics that had been reflected in earlier research (extrinsic; intrinsic; influence; social altruism; security; leisure). We identified four groups of high school seniors in the Class of 2002 based upon their plans for the future (planning both college and military service; planning college; planning military service; planning neither), and compared them on these desired job characteristics. We included in these comparisons data from plebes (freshmen) at a federal military academy. In general, the plebes ranked lower than the high school seniors on the importance of extrinsic characteristics (financial and social recognition); no different on the importance of intrinsic characteristics (interesting work); higher on the importance of influence characteristics (responsibility and decision-making); slightly higher on social altruism characteristics (level of personal contact and service to others); lower on the importance of security characteristics (geographic and personal stability); and lower on the importance of leisure job characteristics (level of free time and supervision, job pace). Exemplary comparisons across all groups on the influence dimension and the security dimension are presented in Figure 2. What our findings suggest overall is that young men and women entering the service academy are not dramatically different from their high school peers, but that the differences that do emerge suggest a generally good fit between the characteristics of military life and the people who aspire to it. Officer candidates are less motivated by a desire for status, prestige, and money; more motivated by a desire for responsibility; more motivated to be of service to others; and less motivated by desires to be able to stay in one place, be free of supervision, and have a great deal of free time than their high school peers.

Figure 2. Influence and Security Job Values Scales

Influence Job Values bar chart across Academic Comparison Groups:
- Neither: 2.47
- MIL Only: 2.65
- College: 2.70
- College/MIL: 2.86
- Plebe (2007): 3.11

Security Job Values bar chart across Academic Comparison Groups:
- Neither: 3.28
- MIL Only: 3.06
- College: 3.25
- College/MIL: 3.07
- Plebe (2007): 2.56

Contributions to Basic Science

This project contributes to our understanding of the attitudes and behaviors of contemporary American youth at the important life-course transition point between adolescence and adulthood, the ways in which work-related attitudes are organized, and the implications of these attitudes for behavior, including service in the armed forces. In part, we have confirmed, though replication, theories about the ways in which work-related attitudes are organized. We have also, through the analysis of patterns of propensity to serve and actual enlistment, contributed to understanding of the relationship between attitudes and behaviors, and the ways in which this relationship varies among demographic groups. At the same time, we have tested hypotheses drawn from existing theories about the ways in which motivations to serve in the military are organized, and while we have confirmed a basic dichotomy between patriotic and

materialistic orientations, we have also shown that the actual pattern of motivations is more complex than that.

Our research on soldiers and their families has helped us to understand the range of tensions that exist at the interface of work life and family life, and the role that family life plays in work performance, satisfaction, and retention. Our research on diversity increases our understanding of how an organization that has traditionally drawn on the dominant majority sector of American society can adapt to the changing demographics of the American labor force.

Potential Army/Military Applications

Our research program on the attitudes and behavior of American youth is relevant for understanding the labor market environment within which the military recruiting process takes place. The U.S. Army Recruiting Command has used the results of this research for several years, it was recently cited in a National Research Council study on the youth population conducted for the Office of the Secretary of Defense, and during the last year it was briefed both to the Reserve Forces Policy Board and to the Chief of Naval Operations' Executive Advisory Panel. Our research on Army families has contributed to the development of ARI handbooks for family support groups and for Army leaders who must provide support for families during deployments, and has been briefed to personnel from the Army personnel chief's office. Our research on the ways in which attitudes and behaviors vary by gender, racial, and ethnic groups has been drawn upon as the Army deals with issues in the management of an increasingly diverse force.

Final Summary

We have analyzed, both in the United States and other nations, the social institutions, attitudes, and values that influence people to select post-secondary school alternatives, and for those who select military service, the processes that influence retention and departure. We found expectations of military service to be declining in the youth population, with variations by gender, racial, and ethnic group. We also found these expectations to be related to motivations to serve, with those who made later decisions to serve being more materialistic. We have found that perceptions of compatibility between military service and family life have an impact on both recruitment and retention. These findings should feed into ARI research on soldier attitudes and opinions, the management of attrition, and strategies to retain quality soldiers. Our research on the young Americans who begin study at a federal service academy shows that on most dimensions, they are similar to their civilian peers. At the same time, there is a realistic understanding of the realities of military life that make service different from most forms of civilian employment. Thus, we find a fit between the individuals who seek a commission, and the conditions of commissioned life. Increasing the reality of expectations and understandings of officer candidate should support ongoing ARI research on officer accession and retention.

Construct Validating Aspects of the Theory of Successful Intelligence Via a Test Battery for Measuring Mental Flexibility

Problem(s)/Research Question(s) - Mental flexibility—the ability to cope with novelty and to establish automatized levels of information processing—is an important aspect of intelligence as it is conceptualized in Sternberg's triarchic theory of successful intelligence. The purpose of this project is to create a new assessment instrument that simultaneously provides partial construct validation of the theory of successful intelligence (Sternberg, 1985) and a means for assessing mental flexibility.

Technical Barrier(s) - There currently exists no broadly conceived test of mental flexibility, hence, a measure is needed that will do justice to the construct.

Significance/Impact for Basic Research - Given the importance of mental flexibility in a rapidly changing world, and the fact that such flexibility is not currently assessed within the framework of conventional psychometric tests, such a test seems to have practical utility as well as theoretical justification. In battlefield situations, circumstances change rapidly, and commanders need to be able to change their plans quickly and effectively in response to changing conditions. For example, the shape of the conflict in Iraq changes continually, and effective response requires flexibility in recognizing the changing posture of the enemy.

Potential Transitions - Knowledge gained in this basic research may be usefully employed in:
- SELECT21: Selection, Classification and Performances Metrics for the Future Force (WP 257) and Selection, Classification, and Performance Metrics for the Future Force Soldier (ATO: IV.HS. 2002.01)
- LEADERSHIP: Developing Leaders in a Changing Army (WP 103)
- Accelerating Leader Development (WP 269) and ATO III.HS.2004.01
- Future Force Warrior Training (WP 215)
- FUTURE-TRAIN: Techniques and Tools for C4ISR Training of Future Brigade Combat Team Commanders and Staffs (WP 211)

Overview

Intelligence tests have always been subject to heavy criticism. One of the most prominent criticisms regards the lack of precision in predicting success in dealing with real-life problems, such as educational or occupation. Thus, it can be questioned whether scores on traditional intelligence tests, taken alone, are optimal for predicting success in problem solving in a rapidly changing world or even whether the traditional concept of "intelligence" is wholly adequate for this purpose. An appropriate assessment procedure should reflect a person's ability to adjust in a flexible manner to changing situational requirements.

The theory of successful intelligence specifies not only the kinds of broad abilities (analytical, creative, and practical) that play a role in achieving success, but also the cognitive processes required to apply these abilities and the problem-solving strategies through which success may be achieved. Within the framework of the triarchic theory of successful intelligence, intelligence is conceptualized on three different levels. On the first level, the focus is primarily on the interaction of cognitive components as the elementary and universal units of information processing (componential subtheory). The second level deals with the relationship of intelligence to the experience of the individual (experiential subtheory). On the third level, intelligence is defined in terms of the context in which intelligent behavior occurs (contextual subtheory).

The goal of this project is to test the experiential subtheory, which specifies that mental flexibility—the ability to cope with novelty and to establish automatized levels of information-processing—plays a critical role in the successful and purposive application of information-processing components to adapting to, selecting, and shaping the environment in novel situations (Sternberg, 1999). Therefore, a multifaceted set of psychometric tests of flexible thinking that measures how well one can apply the components of intelligence in relatively novel tasks and situations has been developed and is currently being piloted.

Research Approach

The theory of successful intelligence differs somewhat from conventional theories of intelligence in its conceptualization of what mental flexibility is and where it belongs in a theory of intelligence. Within this framework, mental flexibility serves as a link between creative intelligence and the experiential subtheory. Creative intelligence allows the individual to apply information-processing components to generate novel and interesting ideas or to build on novel concepts. Both aspects of creative intelligence require mental flexibility as an antecedent for demonstrating creativity. In other words, mental flexibility is a necessary but not sufficient condition for convergent and divergent thinking. Performance on a test of mental flexibility should also provide incremental prediction of success beyond that obtained with conventional, g-based tests. Thus far our assessment battery of mental flexibility contains two major sub-categories of assessment: *Flexible Inference* and *Flexible Mapping*. Let us look at each sub-category of assessment.

1. Flexible Inference: Figure 1 gives an example for an item using shapes for a classification task. Here, the participant must select the pair of answer choices that constitutes the best match to the target on the left side, based on their common properties.
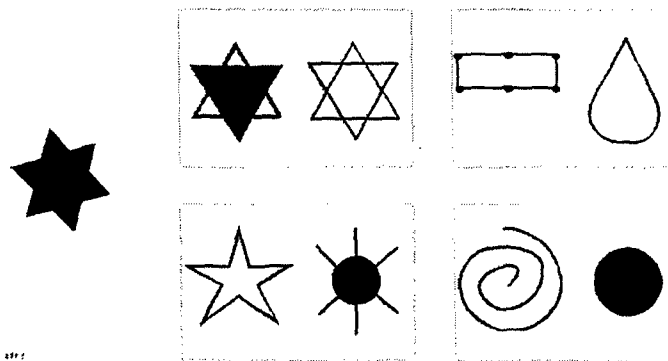
Figure 1. Example of a classification task created for the test for mental flexibility–Flexible Inference (part 1 of the given item triplet).

The correct answer to this item would be the upper left pair, referring to the overall shape that the elements of this pair have in common with the target on the left. Although this paradigm is typically used to assess fluid intelligence, we believe it can be adapted to test mental flexibility. The participant will be confronted next with the same target (on the left side of the screen) and even with the same set of stimuli on the right side, but they are now rearranged (see Figure 2). Because the rule of inference used for the previous problem (star-shape) is no longer valid, the participant's focus must switch to other characteristics. Now, the consideration of the *number* of attributes (dots, spikes, and rays) will lead to the correct answer in this item (lower left pair). The shapes are then presented a third time in yet another arrangement, and the participant must once again infer the relationship that links them together. All items in the Flexible Inference test are thus arranged in item triplets. The stimuli are shapes (as in this example), numbers, or words.
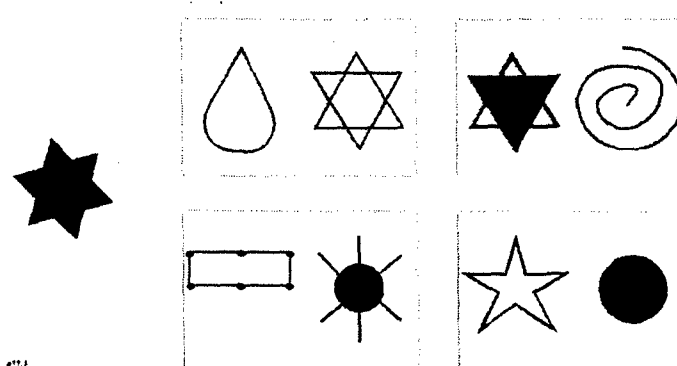

Figure 2. Example of a classification task created for the test for mental flexibility – Flexible Inference (part 2 of the given item triplet).

To be successful on these items, flexible use of different frames of reference for familiar stimuli is necessary. The ability to inhibit experience gained on previous items is the prerequisite for utilizing different cognitive approaches to the same set of stimuli. This paradigm is reminiscent of research done by Gestalt psychologists. For example, the water jug studies conducted by Luchins (1942) showed that people may become biased by experience to prefer certain approaches to a problem, which may then prevent them from identifying the most efficient strategies to solve subsequent problems.

Our approach is based on the assumption that we can utilize the performance differences between two different item classes we have combined in the test. In the Flexible Inference test, items that ask for the inference of *domain-typical* classification rules (e.g., focusing on numerical characteristics in numbers) represent one class. Items that require the inference of classification rules based on *domain-atypical* characteristics of the stimuli (e.g., number of vowels in words) represent the other item class. Every item triplet consists of items from each class.

In the case of the classification tasks (Flexible Inference), we can assume that it is harder to find domain-atypical than domain-typical classification rules. We also expect that it will be more difficult to identify rules when an item (as a part of an item triplet) is preceded by another item using the same target and set of stimuli in which domain-typical characteristics were relevant for its solution. In other words, the *unfamiliarity* or *novelty effect* (domain-atypical characteristics) will be complemented by a *transition effect* caused by the inhibition costs for previous perspectives on the same set of stimuli. Many of us have faced similar problems in learning a second language. The first language is a source both of positive and negative transfer: the more different the second language, the lesser the amount of positive transfer and the greater the amount of negative transfer. When soldiers learn to use new weapons, they must be careful to control for any negative transfer so that they do not use the new weapons improperly, possibly risking self-injury as a result.

Generally, it is expected that the intraindividual variability in performance scores within each item triplet will be indicative of people's ability to use their cognitive resources flexibly.

2. Flexible Mapping: A similar approach is used for another subtest within the test battery for mental flexibility. With the utilization of analogy problems, we seek to gain information about a person's ability to apply a previously inferred rule across different situations. As in the Flexible Inference test, all items are organized in item triplets. The first part of a given item triplet represents a traditional analogy: A relation between the elements of the analogy stem must be inferred, and a rule based on this relation must be applied to complete the analogy. In traditional analogies, the rule must be mapped to other elements from the same domain (see Figure 3a). In our novel tasks, however, we try to broaden the mapping distance by introducing a domain switch within each of the analogy item triplets. For instance, the relation between two numbers (e.g., 88 and 22) must be inferred (the latter is a fourth of the former) and mapped onto another domain so that the same relation between two words (see Figure 3b), or two shapes (see Figure 3c), will complete the analogy correctly.

If the rule is inferred correctly, the participant will recognize that the second term in the analogy stem is one-fourth of the first term. Mapping the rule into the verbal domain will lead the participant to choose "GRANDMA" because a grandmother is one of four grandparents (see Figure 3b). Mapping into the shape domain (as required in the third part of the item triplet) should result in choosing the third answer option. Here the single solid triangle represents one-fourth of the shape given (see Figure 3c).
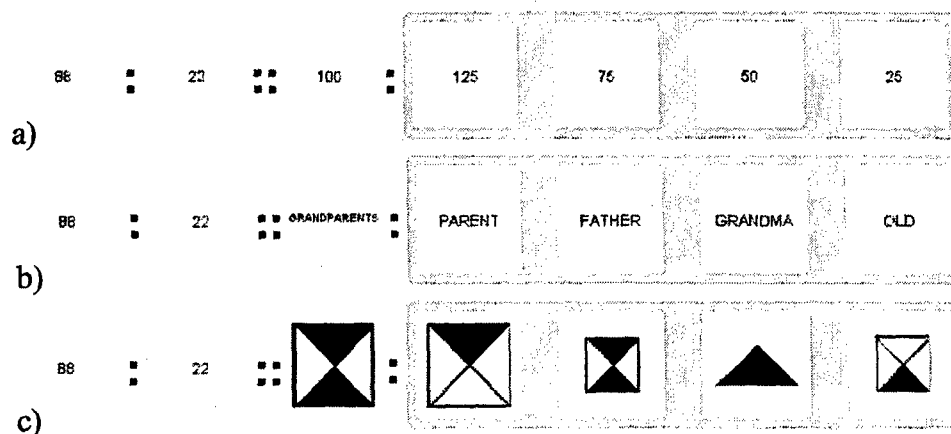
Figure 3. Example of an analogy task created for the test for mental flexibility–Flexible Mapping (a–c: parts 1 to 3 of the item triplet).

The purpose of this procedure is to have an indicator of a person's ability to bridge different mapping distances. Whereas the new classification tasks (Flexible Inference) focus on the ability to infer different relations flexibly, the focus in the analogy test (Flexible Mapping) is on the ability to map rules flexibly.

Similar to Flexible Inference (see classification problems), the item pool of this new assessment procedure also consists of two different classes of items. In Flexible Mapping we have "non-mapping items," where no domain switch is required within the given analogy, and "mapping items," where the domain of the analogy stem is different from that of the application field. Both classes of items are represented in each item triplet. Because of the wider mapping distance to be bridged in mapping items, they are expected to be harder (mapping costs). A person's variability in performance (within each item triplet) will be an indicator for the disturbance the item-class shift causes individually. Our general expectation is that the specific procedure we have deployed in both tests, Flexible Mapping and Flexible Inference, will cause interindividual differences in levels of intraindividual variability in performance on items from different classes.

For validation purposes, we need to map out the correlation pattern to indicators of related but not identical constructs such as creativity, divergent thinking and fluid intelligence. Therefore we chose a set of reference tests to administer together with the tests of mental flexibility. To assess divergent thinking abilities we selected six subtests from the Berlin Structure of Intelligence Test (BIS, Jäger, Süß & Beauducel, 1997). Two subtests referring to the numerical domain, two subtests referring to the figural domain, and two subtests referring to verbal domain represent the marker reference tests for divergent thinking. As a reference test for classification (see Flexible Inference) in the figural domain, we used a figural reasoning subtest from the BIS. As a second reference for classification and adaptive flexibility in the figural domain we used a subtest from Kit of Factor-Referenced Cognitive Tests (F-Kit, Ekstrom, French & Harman, 1976). We also use various subtests from the F-Kit to measure classification in the verbal domain as well as for numerical reasoning ability.

To check whether the performance scores in the new mental flexibility tests are correlated or even confounded with personality characteristics (e.g., openness to experience,

extraversion) to a greater extent than are traditional measures of intellectual abilities, we administered the NEO-Five Factor Inventory (Costa & McCrae, 1985).

Information about high school GPA and first-year college GPA serves as an external criterion for the ability to deal flexibly with the adaptation process to a new learning environment.

Accomplishments

For Flexible Inference we have created an initial item pool of 135 items. Because each item cannot be administered to every participant, the whole item pool was divided into three subsets. Each participant was given 45 items, organized into 15 item triplets. For each domain (numerical, figural, verbal) there are five item triplets for every participant. For Flexible Mapping we also created an initial item pool of 135 items. The same segmentation procedure performed for Flexible Inference was applied to this item pool, resulting in three item-pool subsets. All items are presented via a computer program.

As a first step, the original item pools of both tests were screened by experts and rated for the items' domain typicality vs. domain atypicality in the Flexible Inference test. In a pre-pilot study, the tests were administered to 25 subjects to test the reliability of the computer program, the comprehensibility of the instructions and the screen design. Based on these data and the feedback we received, the instruction phase was improved. After the revision process, we began collecting data from college undergraduates.

We have collected data from 147 (98 female, 49 male) college undergraduates ($18 \leq$ age ≤ 25, mean age: 20.3). During the third quarter of 2004 we recruited subjects from Yale University. During the fourth quarter we are collecting data from undergraduates from Quinnipiac University.

Contributions to Basic Research

According to the theoretical assumptions within the framework of the theory of successful intelligence, mental flexibility reflects the ability to deal with novelty and to establish automatized levels of information processing. To assess this ability we utilized an assessment approach that belongs to the category of dynamic testing. As has been shown in other areas (e.g., for the assessment of learning ability, see Guthke & Beckmann, 2000, 2003; see also Sternberg & Grigorenko, 2002), this diagnostic approach represents a more appropriate way to assess intellectual abilities such as mental flexibility. In contrast to traditional approaches, the focus here is on a person's ability to deal with standardized variations of test conditions. In addition to this methodological improvement, the study will provide further insight into the cognitive processes underlying intelligent behavior while adapting to, shaping, and selecting an environment in novel situations. Furthermore, we may gain another piece of evidence for the validity of the theory of successful intelligence with its broader and therefore better applicable conceptualization of intelligence.

Potential Army/Military Applications

With the increasing diversity of missions Army personnel face, mental flexibility becomes a more prominent need in Army leadership. Indeed, one could argue that mental flexibility is the single most important attribute commanders and subordinates need in order to succeed in today's Army. Therefore, appropriate selection tools are required. By gaining insight into the underlying processes of mentally flexible behavior effective training tools can be developed.

Future Plans

The first goal of the upcoming data analyses will be to test the psychometric qualities of the items and to review and reduce the item pool as necessary. We are particularly interested in internal validity as established by item and factor analyses.

A second goal is to establish the external validity of the new assessment procedures. We expect different levels of novelty of the items to be reflected in different correlation patterns to reference tests. Another goal will focus on the incremental validity of the mental flexibility tests in the prediction of success in dealing flexibly with the adaptation process to a new learning environment while transitioning from high school to college.

Our future recruitment efforts will focus on the necessity to obtain representative samples to cover a wide range of abilities. To fulfill the claim of having a multifaceted test battery for the assessment of mental flexibility, further attempts will focus on the development of other tests, such as counterfactual analogies, where analogies with premises must be solved. The premises should introduce different levels of novelty to the analogy, which should trigger additional mental-flexibility-related variance in the performance data. Furthermore, we will include insight problems (see Sternberg & Davidson, 1995) as reference tests in the study design.

Temporal Investigations into the Relationship Between Affect and Discretionary Work Behavior

Contract #: W74V8H-04-K-0001   **Contract Dates**: 05/01/2004 – 04/30/2006
Institution: Purdue University   **PI**: Howard M. Weiss
                                            Co-PI: Reeshad S. Dalal
                                            Liaisons: Michelle Zyblut, LDRU
                                            Mike Rumsey, SARU

Problem(s)/Research Question(s) – What is the nature of the structure of citizenship and counterproductive behavior at work, collectively known as discretionary behavior? How does this behavior vary over time within individuals and how does the expression of such behavior vary with changes in persons' affective (emotional) states? Also, what are variables that alter the relationship between emotions and discretionary behavior at work?

Technical Barrier(s) – Models of how discretionary behavior changes within individuals and the effects of emotions on discretionary behavior have not been well developed. This gap in the literature existed in large part because the methodological and statistical tools to study such phenomena have not existed until recently.

Significance/Impact for Basic Research – Understanding the structure of discretionary behavior, and the emotion-behavior linkages, will lead to more comprehensive theory and models of human performance.

Potential Transitions – Knowledge gained in this basic research may be usefully employed in:
- SELECT21: Selection, Classification and Performance Metrics for the Future Force (WP 257); and Selection, Classification, and Performance Metrics for the Future Force Soldier (ATO: IV.HS.2002.01)
- Accelerating Leader Development (WP 269)
- Ground Systems Team Training (WP 302)
- Future Force Warrior Training (WP 215)

Overview

In spite of the recent interest in citizenship and counterproductive behavior, as well as their documented importance to organizational functioning, much remains to be discovered about these criteria. Our program of research will incorporate the burgeoning literature on the immediate consequences of momentary affective states (see Brief & Weiss, 2002, for a review of this literature) with the literature on discretionary work behavior. We will conduct a set of studies that explore and map individuals' naturally occurring on-the-job citizenship and counterproductive work behavior, their emotional antecedents, and variables that potentially influence the emotion-behavior relationship. In order to better understand the emotional causes of citizenship and counterproductive behavior, we first have to understand the underlying dimensional structures of this behavior.

There are four main goals of our project. First, we propose to examine the structure of work behavior by determining the co-occurrence of citizenship and counterproductive behaviors

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as well as when people switch between these behaviors over time. The main aims of this study are to determine which behaviors occur together on a given time occasion (i.e., behavioral co-occurrence) and predicting changes from one behavioral state on one occasion to the next behavioral state on subsequent occasion (i.e., behavioral switching). So far, the literature has not examined the possibility that the dynamic structure (i.e., using "time" as the level of analysis) of citizenship and counterproductive behavior may not mirror the static structure (i.e., using "person" as the level of analysis), an oversight that needs to be rectified. The structure of discretionary behavior also needs to be established before we explore its emotional antecedents.

The second study focuses on establishing employees' immediate emotional states as the causes of citizenship and counterproductive work behavior. Research examining the impact of emotional states on citizenship behavior and, particularly, counterproductive behavior is rather meager. Even less understood are the work events that instigate the immediate emotional states and thereby drive the display of this behavior. Although basic research on emotions suggests that momentary affective states have an important influence on both citizenship behavior and counterproductive behavior, an overarching framework for studying these relationships in detail is needed. We will use Affective Events Theory (Weiss & Cropanzano, 1996) as a unifying framework for understanding these relationships in detail. A fundamental proposition of our research is that changes in the likelihood of engaging in citizenship and counterproductive behavior over time are related to changes in a person's affective states. Therefore, in order to test our predictions, we will examine how behavior and emotions change within a person rather than between people. This approach, known as a within-person design, will allow us to study how key events in the workplace and the way supervisors and organizations create and manage these events influence employees' behavior and affective states.

The experience of negative affective states does not always lead to dysfunctional work behavior; similarly, citizenship behavior does not always follow positive affective states. People's ability to "influence which emotions they have, when they have them, and how they experience and express those emotions" should influence whether or not a given behavior is exhibited (Gross, 1999, p. 557). This process, known as emotional regulation, must be integrated into the study of the way emotional states instigate counterproductive behavior. Individuals vary in their ability to regulate their emotions, but situational constraints may also determine whether individuals have the ability to regulate and control their emotions. It is likely that the ability to regulate one's emotions (or lack thereof) will influence the expression of counterproductive and citizenship behavior. By investigating the role of emotional regulation, we will be able to develop a taxonomy of stable regulatory strategies that can be used to control the dysfunctional consequences of emotional states.

Employees' emotions and behavior occur in a work context that can play an important role in facilitating or inhibiting certain behavior following an emotion-instigating event. Therefore, the fourth and final study will examine leaders' ability to regulate their subordinates' behavior, their adeptness at identifying others' emotions, and their skill at managing and altering these emotions in an effort to avert counterproductive behavior on the part of the employee.

Research Approach

Contrary to traditional cross-sectional studies that look at differences in key variables between individuals, we are adopting a within-person approach that examines how variables change within an individual to address our research questions. Given that the structure of

discretionary behavior and the associations between affect and such behavior are constantly changing and temporally sensitive, we will be using a dynamic data collection tool known as Ecological Momentary Assessment (EMA). Ecological momentary assessment has, of late, begun to gain popularity in the organizational psychology literature (Weiss, Nicholas, & Daus, 1999; Alliger & Williams, 1993) because it allows for the quantitative analysis of work behavior in its natural context (Hormuth, 1986) – not only the natural physical context but also its natural temporal context. EMA can therefore be used to examine issues concerning the relatedness of variables within persons over time.

In order to capture events as they occur, we will be asking participants to complete multiple daily questionnaires on Personal Digital Assistants (PDAs) such as Palm Pilots™ for data collection. Because people cannot be surveyed constantly, several different EMA sampling strategies have been developed. Participants can be surveyed upon the occurrence of specified events, or after a fixed or random amount of time has elapsed since the previous survey. Depending on the particular study, the duration of the study will vary; however, surveys will typically last 10-15 working days. Individuals will be asked to provide daily reports about their citizenship behavior, counterproductive behavior, and affective states.

Accomplishments

We have developed our first two studies examining the structure of citizenship and counterproductive behavior, and the relationship between affective states and this behavior within persons over time. We have obtained approval from Purdue University's Institutional Review Board (IRB) to proceed with data collection. In addition, we are in the process of negotiating with a Fortune 500 corporation to secure a site for data collection with employees.

Contributions to Basic Science

Contrary to most traditional models of work performance, our focus on employees' affective states as a predictor of performance will further the existing literature by providing a framework for understanding how emotions influence work behavior over time. In addition, our projects will integrate theories of emotional regulation, affective experiences, and discretionary behavior. In addition to the theoretical contribution, the results of our projects will provide the basis for developing interventions for preventing dysfunctional work behavior through the use of emotional regulatory strategies. Employees may be trained to recognize the interplay between their emotions and performance at work, and supervisors and organizations can develop work environments that would foster affective states that lead to citizenship behavior and discourage counterproductive behavior through the reduction of negative affective states.

Potential Army/Military Applications

Negligent and willful counterproductive/deviant behavior are especially of great importance in the military, where the cost of such behavior during combat operations can often be measured in terms of lost lives: those of civilians, of one's fellow soldiers, and—in cases of excessive brutality and wanton disregard for norms of combat—even of enemy combatants. Consequently, it is no great surprise that the United States military has long recognized the importance of studying counterproductive (also called deviant or delinquent) behavior among its own soldiers (e.g., Bell &

Holz, 1975; Lennon, 1994). Our research is clearly relevant to the U.S. Army in its quest for the "good soldier." Clear implications for training interventions and further applied research in Army settings can be drawn from this research.

The major implication of the proposed research is that behavior and emotions are transient in nature. They are therefore likely to have a dynamic, temporal structure that may not be identical to their static structure. We suggest first determining the temporal structure of discretionary behavior in civilian settings with their inherent lower-intensity stressors, and then conducting more applied research with the military to examine the extent to which previous findings hold up in more extreme situations—e.g., patterns of soldier behavior under enemy fire on the battlefield. This subsequent applied military research can take the form not only of analysis of emotion-behavior and behavior-behavior links in simulated real-time battlefield environments, but also of retrospective investigations into egregious incidents (e.g., soldiers deliberately shooting their own colleagues, executing civilians, committing mutiny against a superior officer, torturing prisoners, etc.) committed by soldiers. Such research would provide valuable "red flags" that, if heeded, could head off extremely serious incidents before they actually occur.

Another implication of our proposed research is that emotional responses to stressful and/or aversive events can be regulated, preventing expression of counterproductive behavior. Emotional regulation strategies can be executed either by the soldier himself or herself, or by the commanding officer. Research on emotion-behavior links and emotional regulation are perhaps even more important in the military than in other settings, given research suggesting that verbal behavior in the military has ambiguous emotional nuances, making correct interpretations of the speaker's intent especially difficult (Wirshbo, 1990). Officers unable to correctly discern their subordinates' emotional states are unlikely to be able to respond with appropriate emotional regulation strategies. Future research in military settings should therefore examine situational and individual differences in emotional judgment related to oneself or others.

Additionally, the proposed research can lay the groundwork for the study of officer-sponsored "climates" that create contingencies between certain behavior and certain outcomes, thereby attenuating emotion-behavior linkages. For instance, an officer who clearly articulates and consistently enforces a fair and non-discriminatory policy of sanctions for poor disciplinary practices may be able to reduce the incidence of such practices regardless of the frequency and magnitude of stressors and consequent aversive reactions experienced by his or her subordinates. The findings of the proposed studies are likely to provide material relevant to courses in leader development and training.

Future Plans

Over the next year, we will complete data collection for the behavioral co-occurrence and switching study, as well as for studies 2 and 3 which examine the relationship between emotional states and discretionary work behavior, and emotional regulation as a moderator. In addition, we will finalize the design of study 4 which will examine the role of leadership on the expression of emotions and discretionary work behavior.